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The Institute of British Foundrymen
The Institute of Vitreous Enamellers
The National Ironfounding Employers' Federation
The Welsh Engineers' and Founders' Association
and
The Foundry Trades' Equipment and Supplies Association

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Amazing Activity

An amazing amount of activity is disclosed by the issue of the omnibus programme of the Branches of the Institute of British Foundrymen. No less than one hundred and sixty-nine items are listed in this programme, in the form of either Papers for discussion, works visits, or social functions—events where without exception one can assimilate knowledge. The number of Branches and sections has now grown to sixteen, and even further efforts are being made to raise this figure by the creation of a new centre of activity at Bristol. If the number of towns where Papers are read be examined the list becomes still more extended.

The membership of the Institute is round about 2,000, and of this number about 7 or 8 per cent. are personally participating in some phase of its activities, for in addition to the normal standing committees there are eight or ten sub-committees dealing with various technical aspects of foundry practice. Thus, unlike many Institutes, there is a reasonable prospect for every member to attach himself to some phase of activity where he can make a useful contribution to the welfare of the industry. By so doing he is bound by the very nature of things to receive more from the Institute than he contributes.

The figures that we have cited show that the Institute is thoroughly democratic in its make-up and, moreover, it opens to its members many avenues for the acquisition of information not otherwise available. It has a permanent contact with sister organisations all over the world, and seven countries are represented on its council. This implies that a member travelling abroad is assured of facilities not normally available. Contacts, often by direct representation, are established with the great professional institutes, the universities, colleges, research associations and standardisation authorities, so that the views of the foundry industry are not allowed to be neglected. It would be invidious to pick out any particular officer for commendation in connection with such an amazing mass of activities, but obviously much directive correlation has to be done, and for this and general leadership the Institute is fortunate in having for its administrative secretary Mr. T. Makemson, who somehow manages to retain year after year such enthusiasm amongst the members that they are spurred on to do an ever increasing amount of voluntary work for the general good of the industry.

Industrial Pensions

Of all the problems associated with industrial work from the point of view of the worker, the most important is that of security against sickness, unemployment, and the hazards of life. Social services undertaken by the State, such as insurance against unemployment and sickness, have gone a long way towards alleviating the feeling of insecurity, and an excellent example has recently been set to the industry by the United Steel Companies, Limited, in their pension scheme, which we understand has been agreed to by an overwhelming majority of those concerned. It should give greater stability in employment as tending to diminish moves to other concerns and assures every worker of a modest retiring allowance. It has been said that the general adoption of similar schemes would remove the major part of what is left of the unemployed by removing from industry those men who should really have retired, but who are compelled to go on working because they lack the means to retire.

The United Steel Companies have adopted the policy of setting aside from each year's profits the amount required to meet the following year's contributions to the pension scheme from the companies. This amounts to no less than £110,000 for this year. A scheme was started last year for the staff, and this year has been extended to cover all workpeople. Both schemes are contributory. The scheme for workpeople provides that at 65 years of age a pension is given equal to sixpence per week multiplied by the number of years served. Thus, a man who is engaged continuously from the age of 21 to the age of 65 retires on a pension of 22s. per week. Naturally, it is smaller for older men, being 10s. per week for a man of 45. For men over 45 who join the scheme from the beginning and who have been in the companies' service, a back-service pension is paid which secures a pension of 10s. per week. The dependents of every man who dies before reaching pensionable age receive a payment of £103, in addition to the pension benefit. The companies pay a bigger proportion of the contribution in the case of men earning less than 50s. per week than for men earning more. The staff and workpeople's schemes in a full year will cost the concern £130,000, less income tax, and the back premiums will be over 40 per cent. of the total cost, but these will end in 14 years. This far-reaching and far-sighted scheme should be examined by every employer.

Composition and Its Effect Upon the Properties of Mould and Core-Sand Mixtures at Elevated Temperatures

AUTHOR'S REPLY TO MR. J. LONGDEN*

Mr. Hudson writes:—Mr. J. Longden's remarks are particularly valuable and it should be clearly understood that any conclusions reached relative to the behaviour of mould and core materials at elevated temperatures, and the effect of the combined properties of expansion and increase of strength on heating on the resulting casting, are based on the title of the Paper, namely, *The Effect of Composition*. It is fully appreciated that many kinds of defects are dependent upon practical conditions, but the scope of the Paper was not intended to cover this aspect of the problem, but rather to indicate the effect of those properties directly connected with the composition of the mould or cores employed and the need for these properties to be taken into practical account as a possible cause of defective work in conjunction with those outlined by Mr. Longden.

It should also be understood that, in an investigation of this nature, every precaution was taken to ensure comparative conditions and one can be assured that the results given in Table III were obtained from moulds rammed by the same man, that venting was adequate and standard throughout, etc.

Mr. Longden's remarks are also of personal benefit as they give one innumerable excuses for future reference to return to the man who plucks up enough courage to try out some of the findings in the Paper and then turns round and blames the sand mixture employed for the defective casting produced.

In regard to the effect of black-wash coatings on permeability, perhaps Mr. Longden will refer to the author's previous Paper on the subject (Foundry Trade Journal, December 5, 1935). In this Paper some evidence is given indicating that the greatest amount of gas generated in the casting of a dry-sand mould may be due to the expansion of the air inside that mould and not generated from the mould materials themselves. This air should preferably be exhausted through the risers, but in certain instances it can be imagined that the risers employed may be inadequate and then a permeable mould surface will act as a natural safety valve. Secondly, whilst it is not suggested that actual mould gases should be exhausted into the mould cavity, it does not follow that such an occurrence is beyond practical accomplishment, and in this event there is more likelihood of a sound casting being obtained by the use of a permeable black-wash coating than the presence of pieces of the coating over the surface of the casting, a probability associated with high gas pressures and impermeable black-wash. However, in all fairness to Mr. Longden, it is personally considered that with our present knowledge on this subject one can make no dogmatic statements and we look to the future for enlightenment.

Life of Ingot Moulds

Mr. W. J. Reagan in the course of a Paper on "Some Factors affecting Life of Ingot Moulds," presented to the American Institute of Mining and Metallurgical Engineers, states that assuming that for the type of steel being manufactured the ingot mould is of the proper design, it seems safe to predict that for a given type of mould, with casting conditions relatively consistent, two factors affect ingot-mould life: (1) wall thickness or mould weight, and (2) chemical analysis of the metal, particularly manganese. Manganese of approximately 1.50 per cent. with silicon of about 1.60 per cent. seems to give maximum mould life. Silicon content of over 1.60 per cent. results in a shortening of the life.

* See Foundry Trade Journal, August 13, p. 123.

Book Review

Kelly's Directory of the Engineering, Hardware, Metal and Motor Trades. (22nd Edition.) Published by Kelly's Directories, Limited, 186, Strand, London, W.C.2. Price 50s. post free.

This edition is ninety pages larger than the previous edition, which appeared in 1934, and includes for the first time particulars of electric lighting, power and traction undertakings.

The following headings, selected from a total of over 2,000, give an indication of the wide scope of the information supplied:—Aerial ropeway contractors; boiler makers; colliery proprietors; cycle agents and dealers; electrical instrument manufacturers; electric lighting, power and traction undertakings; gas works; ironmongers (both wholesale and retail); motor-car manufacturers; motor engineers and garages; rabbit and vermin trap manufacturers; railway plant contractors; steeplejacks; safety-razor makers and tool dealers.

The book comprises the following information:—(1) The names for each county, arranged alphabetically under the towns and villages; (2) an alphabetical classification of trades for the London postal district, with the names arranged under each trade heading in alphabetical order; (3) a similar classification of trades for the rest of England, Scotland and Wales.

There are also the following special sections:—An alphabetical list of the names of some 10,000 branded articles and specialities used in the engineering and allied trades, together with the names and addresses of the manufacturers; an alphabetical list of the names (with addresses) of the manufacturers of iron and steel sections, plates, sheets, etc., arranged under their various classifications, together with the sizes, etc., made by each, and a list of various brands which appear on iron and steel work, together with the makers' names and addresses.

Publication Received

One Hundred Years of Progress. Published (for private distribution only) by Henry Wiggin & Company, Limited, Thames House, Millbank, London, S.W.1.

Firms approaching the centenary of their establishment could study with great advantage this publication, as it is not only very intelligently compiled, but possesses a wealth of artistic merit. Real wisdom has been shown in giving a word picture of Birmingham in 1835, just before the era of the railways, for it serves to indicate the type of world into which entered the creators of Henry Wiggin & Sons, Limited. The actual history of the firm, originally Evans & Askin, is one of real romance; it tells of visits abroad; of the development of nuclear notions; the exhaustion of the raw materials; more journeyings for substitutes; failures of experiments, more experiments and then straight-line progress to continuous and continued prosperity—a prosperity which apparently from the earliest days to the present time the company has shared with its workpeople by according distinctly better working conditions than have prevailed in other shops throughout the century of their existence. Biography occupies a real place in this work as it should do, as, for the major part of its life the firm was a *société anonyme*, but very much the concrete industrial expression of the initiative of a few individuals.

Towards the end of the book an excellent and well illustrated description is given of the works and its equipment, whilst finally there is a complete record of the speeches made on the occasion of the centenary celebrations, a function of which the reviewer still cherishes a pleasant souvenir. Congratulations are offered to those who have collaborated to make this book such a splendid and interesting record.

Random Shots

Now that the "after-dinner speech" season has restarted, "Marksman" thought he would be doing a real service by giving a few stories (obviously not to be retailed in foundry circles owing to prior publication).

* * *

On Co-operation

I was recently being shown around one of the largest mental hospitals in the country, and, noticing the paucity of attendants, remarked it would be rather dangerous if all the patients got together and flouted the rules of the institution. My chaperon aptly remarked: "Idiots never co-operate."

* * *

Variation taken from our esteemed contemporary "The Foundry."

It appears that a foundry owner went to heaven and asked St. Peter if he could meet his earthly competitors. St. Peter replied: "Certainly, because we group the people here by trades." He was taken into a dining hall, and there assembled at one table were many old friends. They all looked exceedingly emaciated; yet they were sitting down to ambrosial dishes served up with lashings of nectar. But closer observation revealed that each one had both his arms in splints so that they could not reach their mouths. His eyes wandered a little farther along the room, and there, laughing and joking, was a crowd of overfed solicitors; yet they, too, had their arms in splints. But the difference was, the lawyers fed one another!

* * *

Chairman (replying to a vote of thanks for presiding): The last time I was in New York, I lifted the receiver of the telephone; gave the number I required; the lady at the other end acknowledged by repeating it, and I said, "Thank you." She said, "Cut out the thanks; it annoys the operator." With the vote of thanks so charmingly proposed by Mr. Jones, and so cordially received by you all, I feel definitely disturbed.

* * *

On Lack of Co-operation

Overheard in a steel foundry with reference to the new metallurgist: "Dr. Twaddle! Dr. Twaddle! What the blazes does he know about moulding; he owt ter get back to 'is panil patients."

* * *

On Misunderstanding

I was with my wife this morning, and I was considerably embarrassed when a young lady addressed me rather severely with the remark: "You, I believe, are the father of one of my children." The situation was relieved when my wife intervened by saying: "I don't think you have met Sonny's new form mistress yet—Miss Jones, etc."

* * *

More Misunderstanding

Entering my hotel fairly late at night at Düsseldorf, I found that I shared the large restaurant with a beautiful young lady who had every appearance of hailing from Paris. She smiled and fondled her key. On retiring, I caught a further glimpse of the young lady just along the corridor. Following habit, I picked up a novel to read myself to sleep, when there were two distinct taps on the wall. I was disturbed, but read another page or two; then came a more insistent tapping. Being of a curious turn of mind, I donned my dressing-gown to explore, and, just as I thought, it was one of those wretched pipe smokers knocking out his pipe.

"Marksman."

The International Foundry Exhibition at Düsseldorf

SOME COMMERCIAL EXHIBITS

In any international exhibition, it can be taken for granted that a large percentage of the commercial exhibits only present real interest to the nationals of the country where it is held. Tariffs and cost of transport naturally prevent the export of much material, and in general only real specialties ever cross the frontiers. It is thus deemed expedient only to deal with those plants shown at the Düsseldorf Exhibition which possess features of interest for our readers.

Moulding Machines

One of the most comprehensive exhibits was shown by the Badische Maschinenfabrik of Durlach, who are represented in this country by Ernest Fairbairn, Limited, of 123, Cannon Street, London, E.C.4. It was a bath making plant and included a complete sand-preparing plant; conveyors for feeding the sand to the moulding machine of the jar-ram turn-over variety; transport facilities for moving the two halves of the mould, and a knock-out. Dame Rumour stated that this plant was destined for erection in the North of England. Badische also showed a special cabinet for sand-blasting the baths.

Amongst other noteworthy exhibits in this section was a fettling machine of the type which uses no compressed air, but projects the chilled shot by means of controlled centrifugal force.

The "Rekord" moulding machine, which is handled in this country by the Selson Machine Tool Company, Limited, of 23, Abbey House, London, S.W.1, and examples of which were shown at Olympia last September, were exhibited by Hartung A.-G., of Berlin-Lichtenberg. This company also showed a series of Herman machines, which are sold in Great Britain by Pneulec, Limited, of Mafeking Road, Smethwick, Birmingham.

One size of each type of moulding machine made by Vogel & Schemmann was demonstrated. These machines work on the well-known principle of shockless jolting whilst the top of the mould is under the influence of a weight. This weight is usually of some standard thickness, and is varied in size in accordance with the size of the box being rammed. Therefore as there is the same weight per unit of surface area on the mould, the resultant ramming is equally hard irrespective of the size of the box.

The plain draw or pin-lift machine shown—Type X.1.—is a comparatively small machine, but it will deal with a moulding-box up to about 20 by 30 in. inside sizes, the actual ramming time for ironfoundry sand being from two to five seconds. The "draw" is oil operated and is automatically accelerated. A turn-over machine of the same type was also shown. This is a particularly robust machine and is extremely fast in operation. The features of particular interest are the accurate "draw" obtained by the use of hardened and ground guides, in addition to the main cylinder which is some three diameters long, and the entire absence of foundation pits or holes to clear the machine during the turn-over. A recent improvement in this machine is in the bolt which releases the machine for turning over. This is now operated by air, thus enabling the control to be at the front of the machine. These machines attracted a very considerable amount of attention. They are sold in the British Empire by Mr. W. J Molineux, of Wolverhampton.

A Sand-Preparing Plant

A rather neat looking sand-preparing plant was shown by a prominent equipment firm. It consists of a sieve, which works the sand over a magnetic drum into a sand thrower, which fills a storage bunker. A clam-shell closure allows a bucket loader sliding up an inclined plane to feed a sand mill. The pan of the mill can be opened by a slide valve to feed a second sand thrower, which fills a second hopper fitted with a clam-shell closure for feeding a truck running on a light railway. It appealed to us as being an intelligent lay-out for a foundry not wishing to mechanise too fully. Another exhibit incorporated a magnet in a sand thrower.

Two Sandfunkers (known in England as the "Sand Wizard") were shown by Vogel & Schemmann A.-G., Hagen-Kabel, Westphalia. They represented two main types of machines, one of which—a rotary barrel 44 in. by 48 in. using two impellers—was on demonstration cleaning various types of steel, malleable, bronze, and grey iron castings. The second was a rotary table machine which was demonstrated cleaning similar castings to those done in the barrel, but of shapes and sizes unsuited to treatment in the barrel. The Constructional Engineering Company, Limited, of Birmingham, handle these machines in Great Britain.

Two core-blowers were being demonstrated. One machine was blowing cores for malleable iron pipe fittings. Four double cores were made simultaneously in one core-box, the production being 350 to 400 cores per hour (700 to 800 castings.) The other machine was shown blowing plumbers' brasswork fittings (taps), the rate of production being similar to the other machine, but there were only four single cores per blow.

The V.S.K. sand-mixer, sold in England by W. C. Holmes & Company, Limited, of Huddersfield, was shown in use reconditioning the sand used on the moulding machines. The chief improvement was a very effective vibratory screen, instead of the usual oscillating riddle over the throwing device.

A small vertical paddle type oil-sand mixer was shown in use producing the sand for the core-blowers. This is a big improvement on the ordinary horizontal paddle type.

Meehanite

There was a homely aspect about the Meehanite stand organised by A. Stolz, A.-G., of Stuttgart. It was superintended by Mr. Rachwalsky, and included castings made by Cameron & Roberton, Limited, Kirkintilloch; Ealing Park Foundry, Limited, and other British licensees.

Drying Stoves

Gusswerke A.-G., Frankenthal, of Rhein-Pfalz (represented in England by Robson Refractories, Limited, of Darlington) were amongst the principal exhibitors of core and mould drying stoves. Their manufactures cover portable, small core and large mould stoves. All are constructed according to Mann patents—a system which is regarded in Germany as of outstanding importance. A claim is made for a temperature difference of only 10 deg. C. between the top and bottom of a 9 ft. high stove, whilst a rapid change of atmosphere ensures drying rather than stewing.

A Core Blowing Machine

Albertuswerke of Hannover-Hamholz, a firm represented in England by Mr. C. W. Coleman, of 156, Strand, London, W.C.2, had the Revolver core blower on exhibit, and it was interesting to compare the specimens of cores made with those decorating the walls of Mr. Coleman's office. Obviously some extremely complicated cores were being regularly turned out by this machine.

A Range of Pneumatic Moulding Machines

Gustav Zimmermann, of Düsseldorf-Rath, who are represented in England by Mr. W. Tait of 6, Harriet Walk, London, S.W.1, exhibited a comprehensive range of pneumatic moulding machines. Space prevented them exhibiting their larger machines, but many foundrymen availed themselves of the opportunity of inspecting these at the company's works.

This firm have a completely self-contained works in Düsseldorf, where they manufacture their own castings, and machine and assemble them. Their drawing offices are very well laid out, well lighted and staffed by experts. They also have a special development department to experiment with any new machines which the firm contemplate manufacturing.

On the stand was exhibited a B.P. machine which is a plain squeeze with oil lifting. Great interest was shown in this machine by the manufacturers of shallow castings. They also showed their well-known range of U.G. machines. Considerable improvements have been made in this type of simultaneous jolt-squeeze machine since its introduction on the market about six years ago. It was interesting to learn that the type of jolter in this small machine is the same in principle as that employed in the large 20-ton shockless machines. On the A.M. machine, which is a jolt-squeeze straight draw, the pattern is lowered from the mould, unlike the U.G. machine, which raises the mould from the pattern.

They also exhibited one of their jolt machines fitted with a weight at the top for flat ramming. Amongst other exhibits was a jolt-squeeze machine of special design for the making of moulds which have chills. It is most important when making this type of mould that the chill remains on the face of the pattern, and the efficiency of this machine was demonstrated by placing a coin on the pattern during jolting; the coin remained in the same place.

As to turnover machines they exhibited their R.P.W.A.2, which is a jolt-squeeze turnover machine with air pattern draw. After turning over the pattern is withdrawn from the mould. Another type shown was the R.P.W.S. 2, which is a spindle lowering machine. After jolting and turning over, the mould is lowered from the pattern by rotating a hand wheel. This enables the operator to lower the mould at a rate suitable for the type of pattern, which is a great advantage over all other machines. We were told that Zimmermann's have recently been supplying a large number of double machines worked by one operator. When working two machines side by side it is often difficult to synchronise the operations. With this double machine both halves are made by the same operation and the moulds can be closed straight away for casting.

A New Airless Sand-Blast Table

The firm of Alfred Gutmann, A.-G., of Altona, whom Fearnley Allen & Company, of Norwich Union Chambers, Birmingham, represent in this country, showed a rotary fettling table in which compressed air nozzles had been replaced by two wheel throwing units. These are mounted eccentrically on a horizontal axis so that the stream covers, in the form of a cone, the whole of the rotating table, and this stream, because of the special mounting, also impinges on the sides of the castings to be cleaned. The volume of grit or sand fed to the wheel unit is controllable by means of a sliding valve. There is no conveyor for returning the grit, this being effected by the suction created by the impeller wheel itself.

The London Industrial Finance Trust announce that a new company, to be known as Hale & Hale (Tipton), Limited, has been formed to take over the business of Thomas L. Hale (Tipton), Limited, specialists in malleable-iron castings. An offer for sale of preference and ordinary shares in the new company is shortly to be made.

D

The Melting Plant at the Foundry of G. & J. Weir, Limited

When we published a description of the works of G. & J. Weir, Limited, of Cathcart, Glasgow, in connection with the fiftieth anniversary of the company, there was expressed a desire to have further details of various sections of the foundry plant. In connection with the melting plant, we are indebted to Mr. D. H. Wood, managing director of the Constructional Engineering Company, Limited, of Titan Works, Charles Henry Street, Birmingham, 12, for the following details. Fig. 1 shows the preliminary lay-out submitted and indicates the general disposition of the plant, whilst Fig. 2 shows reasonably full details of the finished job, such as the fan, hoist and cage-operated overhead travelling crane, with a special arrangement for mechanical charging. One feature of this charging arrangement is that the skip is travelled into the cupola and lowered to approximately eighteen inches above the last charge before the materials are deposited, and before the skip is withdrawn the drop doors are closed. The plant consists of two 6-ft. diameter "Titan" rapid cupolas, fitted with Poumay tuyeres and carrying receivers. Provision has been made for the later installation of a 3-ft. diameter cupola.

Raw Material Storage

In Fig. 2 it will be seen that a series of auxiliary bins has been installed adjacent to the cupolas and from which the materials are charged into the skip. These bins are designed to contain a day's supply of material; the remainder of the bins are for storage purposes.

The crane, when fitted with the electro-magnet, picks up the materials from lorries (there being no sidings) and deposits them into any of the bins.

In the near future we propose to publish an article by Mr. G. E. France, managing director of August's, Limited, of Halifax, on the sand-handling plant installed by his company, in collaboration with the foundry management of G. & J. Weir, Limited, in this foundry.

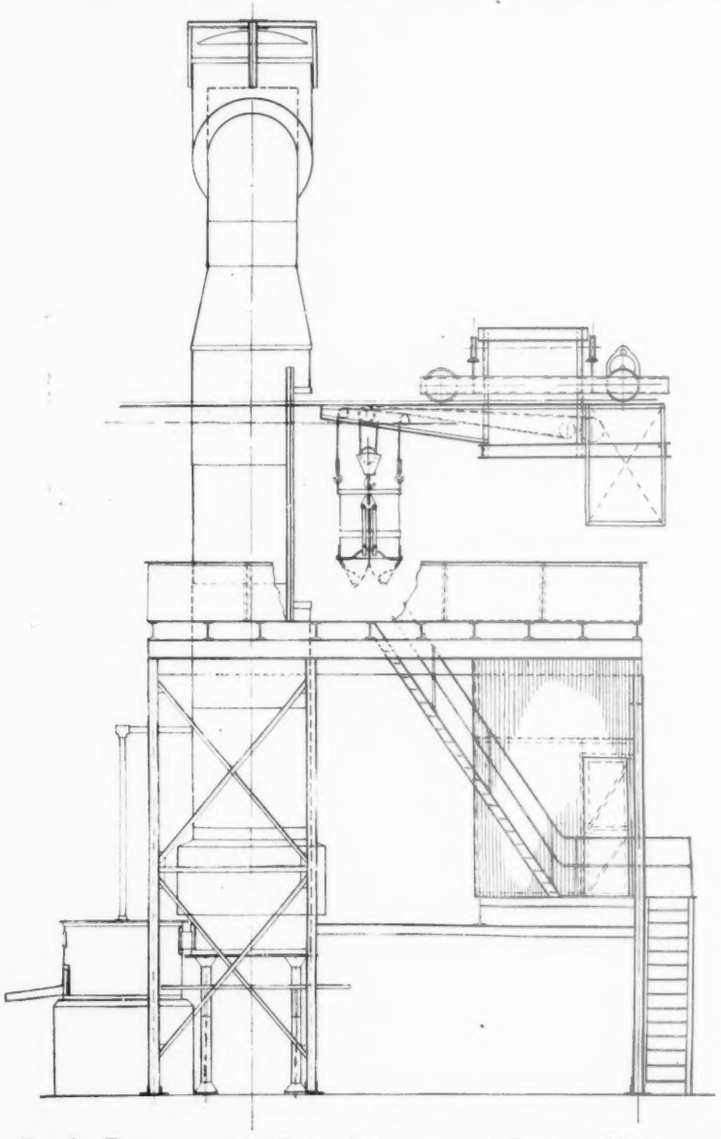

FIG. 1.—ELEVATION OF THE CUPOLA PLANT, SHOWING CHARGING MECHANISM.

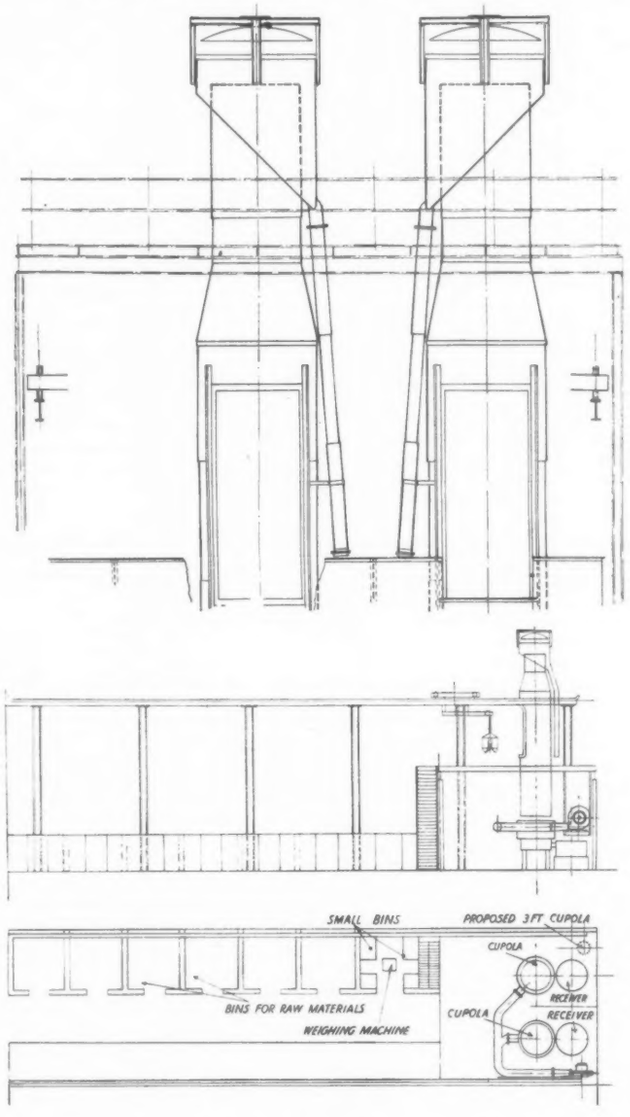

FIG. 2.—LAY-OUT OF THE CUPOLA STAGE, WITH BINS.

Micro-Plasticity in Crystals of Tin

The August issue of the "Proceedings of the Royal Society" contains a Paper by Mr. Bruce Chalmers, B.Sc., Ph.D., on the subject of "Micro-Plasticity in Crystals of Tin," and the Paper has now been issued by the International Tin Research and Development Council as Technical Publication Series A, No. 44.

Many problems relating to the fundamental properties of the metallic state can best be approached through experimental investigations on single crystals of metals. In this investigation the nature and characteristics of the yield point were examined to find out whether the value obtained for the yield point is real or a function of the accuracy of measurement. The relations between tension, length and time for single crystals of tin of high purity were measured by an optical interference method. A number of new phenomena have been noticed, notably plasticity below the accepted yield point, which is called by the author "micro-plasticity." The results are discussed in relation to slip and distortion in the crystal space lattices.

Copies of this publication may be obtained free of charge from the International Tin Research and Development Council, Manfield House, 378, Strand, London, W.C.2.

Second Report of the Steel Castings Research Committee

BY A JOINT COMMITTEE OF THE IRON AND STEEL INSTITUTE AND THE BRITISH IRON AND STEEL FEDERATION

(*Continued from page 270.*)

Foundry Measurements

The approximate foundry methods of measuring shrinkage, though they have some application to the work in hand, usually afford no means of differentiating between shrinkage in the liquid state and that which occurs during solidification, and, since feeding continues to an indeterminate extent during solidification, measurements intended to represent solid contraction only are also affected. Even the simplest method of getting the patternmaker's shrinkage, *viz.*, the casting of a rectangular bar in a well-fed mould of known length and measuring the length of the resulting bar, is subject to some uncertainty, because lack of uniformity of temperature has permitted some of the solid contraction to be compensated by feeding with liquid metal.

Solid Contraction

Measurements of the effect of composition on the solid contraction of steel have been made by Wüst and Schitzkowski[8] by means of an apparatus in which the movement of a plain cylindrical test bar, cast in sand, relative to a rigid framework was measured, and registered, together with a record of the temperature of the bar, on a rotating drum. Taking as a basis a 0.08 per cent. carbon steel free from impurities, Wüst and Schitzkowski prepared steels containing different amounts of silicon, sulphur, phosphorus, manganese, nickel and chromium, and determined the effects of these elements on the contraction. The solid contraction decreased with increase of carbon content from 2.39 per cent. for 0.11 per cent. of carbon to 2.22 per cent. for 0.90 per cent. of carbon. In 12 per cent. manganese steel it was larger (2.78 per cent.) and in 20 per cent. chromium steel smaller (1.88 per cent.), but the variation in solid contraction due to slight differences in composition was very small.

In continuation of this work on the solid contraction of steel, Körber and Schitzkowski[9] have made extensive and accurate measurements of the total contraction, and also of the change of length with change of temperature, revealing the effect of the critical points. The contraction was measured by means of the autographic instrument designed by Wüst, and temperatures were taken by a platinum/platinum-rhodium thermocouple. Experiments were made on (*a*) plain round bars, (*b*) bars with large flanges to hinder contraction, and (*c*) flanged bars, the contraction of which was limited by rigid iron rods placed in the mould between the flanges. There were two series of experiments, one with acid and one with basic open-hearth steels.

The results on the freely contracting bars indicated that the contraction (2.2 per cent.) was independent of the diameter of the bar, and that approximately one-half of the total free contraction occurred before the bars had passed through the critical range. Flanged bars of large diameter, cast in loosely packed green sand, gave almost identical results, and showed, further, that the contraction characteristics of acid and of basic steels were approximately the same. An important part of the work of Körber and Schitzkowski refers to hindered contraction, but this is dealt with in a separate section which follows.

The effect of composition on the solid contraction of cast steels has also been studied by Briggs and Gezelius,[10] and they, also, devoted a considerable amount of attention to the stresses developed when contraction was hindered. In this section, however, free contraction only is considered. This was measured in a solid cast bar of steel by taking readings of Ames dials at both ends. The true contraction was not recorded if one end of the bar was fixed and only the other allowed to contract freely. The pouring temperature of the steel entering the moulds was between 1,582 deg. and 1,538 deg. C. Aluminium was added to the ladle in an amount equivalent to 500 grs. per ton. Data were obtained for a series of carbon steels containing from 0.08 to 0.90 per cent. of carbon, with manganese 0.55 to 0.80 per cent., silicon 0.25 to 0.40 per cent., and phosphorus and sulphur each less than 0.05 per cent. The fact that manganese and silicon variations within these limits made no difference to the final result was first ascertained in a series of preliminary experiments.

The solid contraction recorded decreased with an increase of the carbon content of the steel (Table III). The contraction which occurred before the critical point was reached was similarly reduced, except in the 0.08 per cent. carbon steel. The contraction below the critical range was about the same for all the steels, again with the exception of the 0.08 per cent. carbon steel, which had a slightly higher contraction than the steels with more carbon.

TABLE III.—*Contraction in Freely Contracting Cast Steel Bars (Briggs and Gezelius).*

Carbon. Per cent.	Contraction above critical range. Per cent.	Expansion within critical range. Per cent.	Contraction below critical range. Per cent.	Total contraction. Per cent.
0.08 ..	1.42	0.11	1.16	2.47
0.14 ..	1.51	0.11	1.06	2.46
0.35 ..	1.47	0.11	1.04	2.40
0.45 ..	1.39	0.11	1.07	2.35
0.55 ..	1.35	0.09	1.05	2.31
0.90 ..	1.21	0.01	0.98	2.18

The following summary of the results shows that there is fairly good agreement between the laboratory and foundry measurements of solid contraction:—

Authorities.	Carbon. Per cent.	Solid contraction (as percentage of length of solid at freezing point).
Laboratory measurements described above	Nil to 0.8	Decreases from 2.32 to 2.15 per cent.
Wüst and Schitzkowski	0.1 to 0.9	Decreases from 2.39 to 2.22 per cent.
Körber and Schitzkowski	0.15 to 0.5	(Average 2.20 per cent.)
Briggs and Gezelius	0.1 to 0.9	Decreases from 2.47 to 2.18 per cent.

Freezing Contraction

By converting their linear measurements into volume changes and comparing them with the specific volume of the liquid at the freezing point derived from the data of Benedicks, Ericsson, and Ericson, Briggs and Gezelius deduced a value of 0.0039 c.c. per g. for the solidifying contraction of 0.35 per cent. carbon steel. This is, as they express it, 2.7 per cent. as calculated on the specific volume of the liquid, or 3.0 per cent. of the specific volume of the solid at atmospheric temperature.

Attempts to measure the total shrinkage from the liquid condition down to the moment of complete solidification generally consist of comparing the weight and volume of an unfed cast specimen with those of a similarly cast round specimen cast under conditions of adequate feeding. Several investigators, working with different forms of test-piece, have calculated the liquid and solidification shrinkage of cast iron by this method. A Paper by Saeger and Ash[11] reviews various methods which have been proposed and used for different metals.

A useful method of studying shrinkage, which has been applied to non-ferrous metals, but hitherto only on a very small scale to steel, is that devised by Pilling and Kihlgren[12] (Fig. 5). The test-piece consists of a cylinder, 3 in. in dia. and 3 in. long, with the axis horizontal, fed from below through a thin gate, $\frac{3}{16}$ × 1 in., and supplied with two $\frac{1}{4}$-in. vents. The down-runner, 1 in. in dia., carries a pair of ribs, 3 in. long, for the measurement of the solid contraction. The mould is filled completely with metal as near to its freezing point as possible. The narrow vents and gate quickly solidify and prevent all feeding of the cylinder, while the ribs attached to the down-runner are well fed.

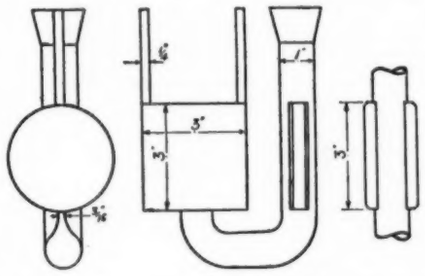

FIG. 5.—SHRINKAGE TEST SPECIMEN. (PILLING AND KIHLGREN.[12])

Assuming that the metal is cast at its freezing point to eliminate liquid contraction, then if

V = volume of cylindrical mould, obtained by filling it with mercury,
V' = volume of metal in cylinder at room temperature, excluding all voids,
v = total shrinkage in volume to room temperature,
w = weight of unfed casting,
d = density of metal,

then $v = V - V' = V - \frac{w}{d}$, and

the total shrinkage, per cent. $= S = 100\,\frac{v}{V} = 100\left(1 - \frac{w}{Vd}\right)$.

By the use of this method Pilling and Kihlgren obtained for carbon steel (C 0.25, Si 0.2, Mn 0.6 per cent.) a total volume shrinkage of 11.4 per cent. The solid contraction measured on the solid ribs was 2.52 per cent., corresponding to a volume shrinkage of 7.6 per cent., leaving 3.8 per cent. for the contraction on solidification expressed as a percentage of the volume of the mould, *i.e.*, the volume of the liquid steel, or about 4.2 per cent. of the volume of the steel at room temperature.

Some experiments on this method of measuring contraction have shown that it may be subject to considerable error. Actual measurements of solid contraction on the ribs gave values ranging from 0.03 to 0.045 in. in the 3-in. length, which is rather less than the usual patternmaker's shrinkage ($\frac{7}{16}$ in. per ft. = 1.56 per cent.), and considerably less than the dilatometrically measured contraction. The values on so short a length are in any case uncertain, and the solid contraction was therefore calculated from the more accurately known values of linear contraction. Other difficulties were found to arise in the operation of this method. If the steel is very near to its freezing point when cast, an irregular surface is obtained in the casting, which means that the liquid metal has not properly filled the mould. It is difficult to correct

for these irregularities, and, unless they are corrected for, the result will be high. A sufficient amount of superheat is necessary to ensure a smooth surface. The mould must not be filled too quickly, since, although a perfect external appearance may be obtained, a large volume of air may be entrapped if the risers are prematurely sealed by solid metal. An example of the calculation and the results of a series of tests is given in Table IV. The total contraction increases with the carbon content, and as the solid contraction simultaneously decreases, the freezing contraction increases to a slightly greater degree.

Table IV.—*Freezing Contraction of Carbon Steels Measured by Pilling and Kihlgren's Method.*

Example of calculation. *Casting* PJK.1. 0.40 *per cent. carbon.*

Volume of mould	=	367.0 c.c.
Weight of cylinder	=	2,545.2 g.
Density of metal	=	7.82
Volume of metal in the cylinder	≐	2,545.2/7.82 = 325.5 c.c.
∴ Total volumetric shrinkage	=	367.0 c.c. − 325.5 c.c.
	=	41.5 c.c.
	=	11.3 per cent.
Solid volumetric shrinkage (deduced from other determinations)	=	7.0 per cent.
∴ Freezing shrinkage	=	11.3 − 7.0 = 4.3 per cent.

Carbon. Per cent.	Total contraction. Percentage of volume of mould.	Solid contraction.* Per cent.	Freezing contraction.† Per cent.
0.10	10.4	7.2	3.2
0.40	11.3	7.0	4.3
0.45	11.1	7.0	4.1
0.70	12.1	6.8	5.3

* Percentage of volume of solid steel at freezing point—derived from other measurements.
† Percentage of volume of liquid steel; add 0.1 to 0.2 to obtain percentage of volume of solid steel at freezing point.

No great value can attach to these figures as an accurate measurement of the freezing contraction, since they must necessarily contain some part of the liquid contraction which precedes solidification. They must, therefore, be too high, but it is of interest to see that they show an increased total contraction with increase in carbon content and are thus in approximate agreement with the conclusions set out earlier.

An experiment with a 2.0 per cent. aluminium steel gave a freezing contraction of about 6 per cent. and did not bear out the suggestion that aluminium reduces the contraction on solidification.

The Effect of Practical Conditions on Shrinkage

In the section on "Laboratory Measurements" the change in volume which occurs as the steel cools from the liquid condition to atmospheric temperature was divided into three distinct stages: (i) Liquid contraction, (ii) contraction on solidification, and (iii) contraction of the solid; and definite values, in so far as they are known, were assigned to each of these changes. These values have been approximately confirmed by tests, described under "Foundry Measurements," made on cast bars of steel. It will be admitted that their accuracy leaves much to be desired, but even if still more accurate data were available and the variations with differences in chemical composition (which are evidently slight) were fully worked out, application to practical casting problems would be remote.

A numerical value for liquid contraction, considered as a physical constant, can only be applied to a given mass of liquid cooling uniformly and without any local differences of temperature. Contraction on solidification, expressed as a constant, applies only to the change occurring in a mass of metal as it freezes at a constant temperature or over the freezing range. Similarly, solid contraction, expressed as a physical constant of the material, applies only to a bar of metal cooling uniformly and without external constraint.

If, on the other hand, a casting can be fed perfectly until the moment of solidification, the liquid contraction does not affect the practical shrinkage; and if the feeding can be continued throughout the freezing range, neither does the contraction on solidification. In these circumstances, if solidification occurred at the same moment throughout the whole casting, the patternmaker's shrinkage would be due entirely to solid contraction and would be closely related to the true thermal expansion of the material. In actual practice it differs from this, however, and is almost invariably less than the amount predicted from the measured thermal contraction of a solid bar, or from such foundry tests as those described above, even after allowance has been made for the slight enlargement of the mould which necessarily occurs during the removal of the pattern.

One reason for this is to be found in hindered contraction, discussed in the following section; but even if this is avoided, another important reason would remain, in that temperature gradients necessarily exist in the mould and that cooling is already occurring in those parts of the outer wall which solidify first while the central regions of the casting are still being fed with liquid metal. A considerable amount of solid may thus form before solid contraction of a continuous outer shell comes into play. Down to a certain temperature solid contraction of part of a casting is therefore balanced by simple flowing-in of the liquid, until a continuous outer shell is formed. The ultimate shrinkage represents the total solid contraction less the amount that has been neutralised by the access of fluid metal. It is this absence of uniformity of temperature over the section which robs shrinkage of the rigid character of a physical constant, and makes it possible to reduce the actual shrinkage in a particular casting to a minimum by careful control of the conditions of solidification.

Briggs and Gezelius[10] have provided a very complete discussion of the effect of directional solidification on the soundness of steel castings. By controlled directional solidification, an attempt may be made to minimise the detrimental effects of contraction.

The effect of conditions in the mould on the shrinkage of the casting has been discussed in a comprehensive way, but with special reference to aluminium alloys by Scheuer.[13]

In the discussion of the second Paper of Briggs and Gezelius,[10] J. H. Hall emphasised the importance of the influence of the casting temperature on contraction. He suggested that variations in the pouring temperature would in practice affect the amount of solid contraction below the freezing point.

The same point has been raised in another connection by Bauer and Sieglerschmidt[14] in a Paper on "Influence of Experimental Conditions on Shrinkage." They found that when a 16:84 antimony-lead alloy was cast in a yoke, and the difference in length between the mould and test bar was measured, the results were not constant, but depended on the rate of cooling and on the shape and size of the casting. In view of these indications it is desirable that further information on the effect of casting temperature and rate of pouring on the actual contraction occurring in a steel casting should be obtained.

Hindered Contraction

Hindered contraction has been mentioned as one of the reasons why the full theoretical shrinkage does not occur in practice. Some hindrance to contraction cannot be entirely avoided in practical casting, though it is essential that it should be kept at the lowest possible limit in order to avoid the risk of tearing.

Körber and Schitzkowski[9] found that in loosely packed green sand a 100-mm. dia. flanged bar showed approximately the same contraction as a plain bar, *i.e.*, 2.2 per cent. but that a similarly flanged 20-mm. dia. bar contracted only 2 per cent. In dry-sand moulds, made from a mixture of schamotte, clay and graphite, the recorded contractions were much smaller, *viz.*, 0.34 to 1.78 per cent. according to the size of bar. In these moulds all the flanged bars fractured, the autographically recorded contraction showing a deviation from the normal curve at about 1,300 deg. C. The smaller bars were broken almost through, but in the larger diameter bars the fracture extended only partway across the section. In no case, however, did the fracture show any plastic deformation.

In a further set of experiments the contraction of 30-mm. dia. flanged bars, cast in a green-sand mould, was impeded at different stages of cooling by iron rods of different lengths placed between the flanges. Pronounced tearing was obtained when the contraction was impeded before the temperature fell below 1,200 deg. C.

The critical temperature at which cracks are most liable to be formed is shown by the foregoing experiments to be about 1,250 to 1,300 deg. The best, and very usual, method of avoiding cracks is to loosen or break up the mould immediately the metal has set, before it cools through the temperature 1,300 deg. C.[15] The time which elapses before this temperature is reached depends on the mass and cross-section of the wall of the casting, and also on the casting temperature, temperature of the mould, and the thermal diffusivity of the mouding sand. For castings with a thin wall this period is very short. Values obtained by Körber and Schitzkowski, together with their estimate of the times required to reach Ar_1 are given in the following tabulation:—

Diameter of bar.		Casting temp. Deg. C.	Time required to reach—	
Mm.	In.		1,300 deg. C.	Ar_1.
			Min.	Min.
20	0.79	1,480	1	5
30	1.18	1,460	2	15
30	1.18	1,500	3	—
40	1.58	1,490	5	26
50	1.97	1,480	6	37
100	3.94	1,510	8	67

In an important part of the work of Briggs and Gezelius[10] the cast bars were restrained from contracting by springs of three different sizes operating to produce tension in the cast bars as they cooled from the freezing point. The results obtained (Table V) indicate that, under constraint, the contraction is reduced by an amount which varies with the applied tension, while the expansion at the critical range is increased. The temperature of the critical range was not affected. Under the influence of a given spring there was, with increasing carbon content, an irregular but slight increase in contraction above the critical range, while the contraction below the critical point was constant or slightly diminished. The E spring, under which a total contraction of 1.56 to 1.79 per cent. was obtained, probably reproduced most nearly the normal stresses encountered in the ordinary com-

mercial casting, as the total contraction recorded under the tension of this spring approximates to the patternmaker's shrinkage of $\frac{3}{16}$ in. per ft. or 1.56 per cent.

Briggs and Gezelius called attention to the fact that the contraction undergone by low-carbon steel on cooling down to a temperature of 1,300 deg. was much greater than that of high-carbon steels cooled to the same temperature, and, in fact, was as great as that of a high-carbon steel cooled to 1,090 deg. C. On the

TABLE V.—*Contraction of Cast Steel Bars Restrained by Springs (Briggs and Gezelius).*

Carbon. Per cent.	Contraction above critical range. Per cent.	Contraction within critical range. Per cent.	Contraction below critical range. Per cent.	Total contraction. Per cent.
		Strong C *spring.*		
0.08	0.15	0.14	0.45	0.46
0.14	0.17	0.13	0.44	0.48
0.35	0.20	0.15	0.42	0.47
0.45	0.21	0.14	0.41	0.48
0.55	0.24	0.13	0.40	0.51
0.90	0.20	0.06	0.38	0.52
		Medium G *spring.*		
0.08	0.32	0.22	0.76	0.86
0.14	0.35	0.22	0.75	0.88
0.35	0.46	0.24	0.70	0.92
0.45	0.49	0.20	0.66	0.95
0.55	0.52	0.18	0.73	1.07
0.90	0.44	0.09	0.77	1.12
		Light E *spring.*		
0.08	0.80	0.27	1.03	1.56
0.14	0.96	0.27	0.90	1.59
0.35	0.92	0.18	0.90	1.64
0.45	0.90	0.13	0.90	1.67
0.55	0.92	0.15	0.95	1.72
0.90	0.88	0.04	0.95	1.79

assumption that the range in which liability to cracking was most pronounced was always about 1,300 deg. C., they pointed out that if the strengths of the 0.14 per cent. and the 0.35 per cent. carbon steels were identical at a given temperature, the danger of the formation of hot tears would be greater in the 0.14 per cent. carbon steel. The rate of contraction and therefore the rate of increase of stress is greater, according to these experiments, for the low-carbon steel. With increase of stress, however, there must also be taken into consideration the capacity of the steel to undergo deformation without fracture, and in this connection mechanical tests on cast steel at temperatures approaching the melting point are of importance.

The Strength and Ductility of Steel at Temperatures near the Melting Point

It has long been recognised that "tears" in steel castings are produced at a very high temperature. Körber and Schitzkowski,[9] in the work referred to in the last section, placed the temperature of formation of these cracks at about 1,300 deg. C., and Briggs and Gezelius[10] distinguish between internal hot tears that develop during the solidification of the casting and external hot tears that develop after solidification is complete, but while the temperature is about 1,300 deg. C. The former type is in the nature of a cavity, the latter of a crack.

Although much information is available on the strength of cast steel at temperatures up to 500 deg. C.,[16] and a little is known of the strength of steel in both the cast and the forged condition at temperatures approaching its melting point, no systematic study has been made of the strength and ductility of cast steel as it cools in the mould. It is, therefore, gratifying to be able to issue as a part of the present Report the preliminary results of an investigation dealing with this subject, carried out in the Research Department, Woolwich, by Mr. H. F. Hall. This work provides information as to the temperature at which the steel acquires ductility and below which contraction stresses have a relatively harmless effect.

In the present section, data having reference to the strength and ductility of steel which has been reheated from atmospheric to very high temperatures are collected.

In 1900 Le Chatelier[17] found that the reduction of area of mild steel increased between 450 and 900 deg. C.; after showing a bend at 900 deg. C., the curve again rises to a value of 95 per cent. at 1,200 deg. C.

Rosenhain and Humfrey[18] took observations of the tensile strength of electrolytic iron and of 0.1 per cent. carbon steel after it had cooled *in vacuo* from 1,100 deg. C. The curve of tensile strength at different temperatures showed discontinuities at 900 deg. C. and at 720 to 750 deg. C. The value of the tensile strength of iron at 1,100 deg. C. with a rate of straining of 0.012 in. per sec. per in. was 5,000 lbs. per sq. in.; with a rate of straining of 0.0005 in. per sec. per in. it was about half that amount. The elongation yielded irregular results, and the reduction of area was not measured.

The work of Dupuy[19] does not confirm the existence of such sharply defined charges in strength at the critical temperatures, but the test-pieces used by him were of a form which would be less sensitive in revealing sudden changes in strength. From his results certain points of interest emerge concerning the properties of cast steel reheated to very high temperatures.

(1) At 1,250 deg. C. and above, the tensile strength, irrespective of the carbon content, never exceeded $1\frac{1}{4}$ tons per sq. in. As the temperature of testing approached the melting point, it was further reduced to 0.8 ton per sq. in. and then fell to nil. These values must, of course, depend on the rate of straining, which is not clearly given. It is, however, stated that an overall rate of straining of 12 mm. per min. was employed, and that the "acting length" of the test-piece was 110 mm.

(2) The reduction of area fell at temperatures just above Ac_3, but increased again above 1,000 deg. C., reaching 100 per cent. at a temperature of 1,100 to 1,200 deg. C., and remaining at that figure up to the temperature of incipient fusion. There appears to be no evidence in Dupuy's results of a fall in the reduction of area before incipient fusion, but no mention is made of any test above 1,250 deg. C., with one exception, *viz.*, cast 0.55 per cent. carbon steel at a temperature "towards 1,400 deg. C."

The total absence of reduction of area in this instance was attributed to incipient melting, causing a "sudden and simultaneous fall in the breaking stress and the plasticity."

The tensile strength and reduction of area of cast steel from 650 to 1,450 deg. C. was investigated in greater detail by Piwowarsky, Božić and Söhnchen,[20] who also dealt with the influence of crystal orientation. Test-pieces were cut from rectangular blocks (cast in sand moulds inset with steel chills to promote transverse crystallisation) across and along the direction of growth of the dendrites. At temperatures up to 850 deg. C. tests were made in a 10-ton testing machine. At 950 deg. C. and above a special form of apparatus was employed. Tests were made on Bessemer, acid and basic open-hearth and electric-furnace steels, details of which are given in Table VI. In all cases the tensile strength decreased with increase of temperature. There was a rapid decrease from 650 to 750 deg. C., but the rate of fall was checked at the α-γ change. The influence of orientation of the crystals on tensile strength was not very great, though up to 1,000 deg. C. the strength perpendicular to the direction of crystal growth was generally slightly higher than in the direction of crystallisation.

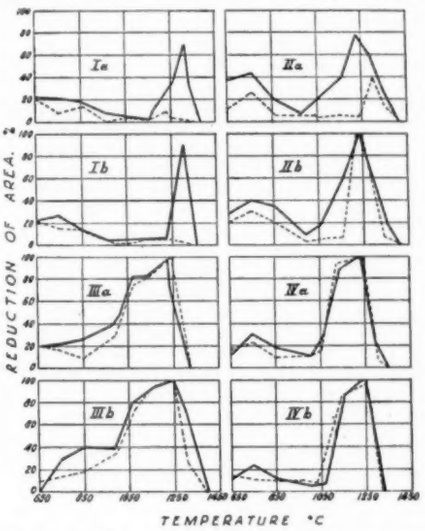

FIG. 6.—REDUCTION OF AREA IN RELATION TO TEMPERATURE AND DIRECTION OF CRYSTALLISATION: (FULL LINE, ACROSS THE DENDRITIC CRYSTALS; DOTTED LINE, ALONG THE DENDRITIC CRYSTALS) I. ELECTRIC FURNACES; II. BESSEMER; III. BASIC OPEN-HEARTH; IV. ACID OPEN-HEARTH.

TABLE VI.—*Chemical Composition and other Data with Reference to the Steels Investigated (Piwowarsky, Božić, and Söhnchen).*

Type of steel.	C. Per cent.	Si. Per cent.	Mn. Per cent.	P. Per cent.	S. Per cent.	N_2. Per cent.	O_2. Per cent. (1)	O_2. Per cent. (2)	SiO_2. Per cent.	Al_2O_3. Per cent.	Tensile strength. Nil at—	Reduction of area. Nil at—	Deoxidised with—
											Deg. C.	Deg. C.	
Electric furnace steel *a*	0.26	0.49	0.76	0.054	0.013	0.004	0.0143	0.0171	0.010	0.025	1,390	1,375	(3)
Electric furnace steel *b*	0.22	0.35	0.78	0.063	0.025	0.004	0.0061	0.0141	0.007	0.022	1,370	1,350	(3)
Basic open-hearth steel *a*	0.30	0.35	0.60	0.069	0.079	0.006	0.0038	0.0143	0.002	0.027	1,400	1,350	Ferro-silicon
Basic open-hearth steel *b*	0.34	0.34	0.62	0.084	0.080	0.006	0.0051	0.0155	0.002	0.022	1,410	1,275	Ferro-silicon
Acid open-hearth steel *a*	0.35	0.29	0.60	0.029	0.037	0.004	0.0088	0.0141	0.000	0.030	1,360	1,270	Ferro-silicon
Acid open-hearth steel *b*	0.41	0.33	0.73	0.025	0.028	0.005	0.0057	0.0196	0.010	0.035	1,410	1,390	0.02 per cent. Al
Bessemer steel *a*	0.18	0.23	0.77	0.102	0.134	0.006	0.0180	0.0277	0.025	0.036	1,460	1,410	0.02 per cent. Al
Bessemer steel *b*	0.28	0.51	1.26	0.100	0.085	—	0.0070	—	—	—	1,440	1,410	0.02 per cent. Al

(1) By hot extraction method. (2) By residue method. (3) Deoxidised with ferro-manganese and ferro-silicon, with the addition of 0.5 kg. Al per ton in the ladle.

At atmospheric temperature, the tensile strength of the basic open-hearth steels was as follows:—

Melt.	Along the crystals.	Across the crystals.
	Tons per sq. in.	Tons per sq. in.
a ..	32.0	34.2
b ..	33.6	34.8

Above 1,000 deg. C., the differences disappeared; all steels at this temperature had a tensile strength of about $2\frac{1}{2}$ tons per sq. in., which fell towards zero with rise of temperature to 1,350 to 1,450 deg. C.

(*Continued on page* 296.)

What the Engineer Should Know About Cast Iron

MR. ROXBURGH'S PRESIDENTIAL ADDRESS

The Sheffield Branch of the Institute of British Foundrymen held the first meeting of the 1936-37 session at the King's Head Hotel, Sheffield, on October 1, when the new Branch-President (Mr. J. Roxburgh, foundry manager of Davy Bros., Limited) delivered his inaugural address.

Mr. A. Whiteley (retiring President), who occupied the chair at the opening of the meeting, inducted Mr. Roxburgh to the chair, and remarked that Mr. Roxburgh really took office at the Glasgow Conference. He thanked the Branch, the Council, and especially the secretary (Mr. T. R. Walker) for all they did for him during the period of his Presidency. This year they had a noted foundryman as chairman, and he asked them to receive Mr. Roxburgh and his Presidential Address with more than usual enthusiasm.

Mr. J. Roxburgh, who was received with applause, proposed a hearty vote of thanks to Mr. Whiteley for the excellent manner in which he had carried out his Presidential duties. Nothing seemed to have been too much trouble for Mr. Whiteley, and his powers of organisation were to be envied.

Mr. G. L. Oxley seconded the resolution.

Mr. Whiteley, returning thanks, said it had been a privilege to occupy the Presidential chair. He had had the interests of the Branch at heart for a long time, having been a member 19 or 20 years. Now that he had terminated office, he did not propose to let that interest flag, and if there was anything that he could do for the Branch or for any individual member, he should be glad to do it.

Mr. Roxburgh then delivered his Presidential Address on "Developments in the Iron Foundry," in the course of which he said:—

Mr. Whiteley and Gentlemen,—

Engineers, generally speaking, do not think too kindly of the foundry, nor do they place much faith in cast iron as an engineering material, except within their own idea of limits. Possibly this arises from the fact that they do not know sufficient about modern development in the foundry, so this opportunity has been taken to consider such matters, in an endeavour to help the engineer to view the foundry and its products in their proper perspective.

It would be as well, initially, to tell them candidly what the foundrymen do *not* claim (which, incidentally, will entail certain pertinent admissions), and later to refer to what they do definitely claim, in regard to their practice, so that the position will be the more clearly understood to their mutual benefit. It is useless trying to hoodwink the engineer; he generally knows what he wants, and grumbles if he does not get it, though at times one is not precisely aware of his exact demands.

Where Progress is Lacking

It has to be confessed that the ordinary types of castings supplied to-day are probably no better than those made many years ago. In other words, the individual skill of the craftsman to-day is on no higher plane, and, as in other skilled industries, there is a scarcity of skilled men. Ordinary castings, involving no special service conditions or tests from the engineer, are made, in the majority of cases, precisely as they were in years gone by; the same mixture of metal is charged in the cupola, and to all intents and purposes, the practice observed throughout is the same. This obtains in practically all jobbing foundries, which largely comprise the foundry industry. As regards repetition foundries, moulding machines were introduced many years ago, but certain foundries specialising on castings for which there is a definite and regular demand are using continuous casting plants. These have increased production, and have enabled the management to ascertain exact costs, to control the raw materials used, and to institute a fuller control of the practice involved. It will be granted that this almost invariably results in an improved product, due to concentrated effort under more scientific control.

The ordinary types of pig-iron available to-day for foundry use, possibly, are slightly inferior to those used in the past, but their manufacture is entirely outside the control of the foundries. It would appear, superficially, that the blast-furnace, with its fiercer drive, hot-blast air and larger output, has had to sacrifice quality of iron to production. At any rate, the founder can easily overcome this difficulty, where necessary, by addition of refined irons, produced by the modern types of furnaces, which definitely give an improved product. Defective castings are still as much in evidence to-day as ever, wherever such castings depend entirely on the skill of the foundryman.

An Articulate Grouser

Some time ago a well-known engineer, in a lecture, deliberately set out to take the foundryman to task. He deplored the fact that so many bad castings had passed through his hands, and expressed disappointment, too, that foundries did not appear to have developed to the same extent, as, for instance, the machine shop, though he withdrew the latter in favour of a fitting shop as a fairer comparison. He quoted instances and showed illustrations of certain defective castings in regard to unsoundness, porosity, lack of pressure-tightness, draws, warping, cores out of centre, and other faults. The engineer is obviously much annoyed when a casting has had to be scrapped, and especially so at an advanced stage in machining, having in mind the cost involved as far as he is concerned, for which he is not recompensed, and also the delay caused in waiting for a replacement.

Invariably, the foundryman conducts an inquest on all wasters; but, on the other hand, the defective castings themselves are bound to receive a great deal of spotlight attention, so that the engineer may be apt to estimate the frequency of their occurrence out of all proportion to the real facts. Probably, in most of the jobbing foundries in this country a figure of 5 per cent. for wasters, from all causes, is frequent, although the class of work has to be taken into consideration. Some repetition foundries are able to get down to a figure of less than 1 per cent.

Founders, including the non-ferrous and steel sections, will concur that they have not yet reached that ideal state when they can guarantee to supply a perfect casting, nor be completely assured, in their own minds, of the definite reliability of their finished products. At any rate, on the one hand, foundrymen can pride themselves upon being the actual creators of new articles from raw materials, in which process of manufacture skill of the highest order is demanded, but, on the other hand, with so many variables to control, uncertainty has not yet been eliminated.

The Other Side of the Picture

It is submitted that the advances which have been made are connected with technical knowledge, applied both to the mechanical aspects of the industry and to the numerous technical considerations associated with foundry practice. With regard to the mechanical side of the business, founders are indebted to the engineer—the foundry engineer as he is called to-day—for the important part he has played in affording plant for the work of mechanising and improving the various operations peculiar to the foundry. Mechanical-handling plant for sand and metal, the continuous-casting plants previously referred to, moulding and coremaking machines, conveyors of all types, stoves, fettling and cleaning appliances, and other apparatus have been designed to give continuity where desired, and speeding-up of operations. Such plant is used wherever possible in all types of foundries, and other mechanical aids, of service also to the jobbing founder, are sand-slingers, pneumatic rammers and jolt machines, where jobs can be suitably adapted.

Better Melting Facilities

Melting equipment has been improved, and new types of furnaces have been introduced to give the founder improved material. The provision of metal which is of higher temperature, cleaner, and more closely controlled as regards analysis and structure, has received attention. The cupola is still, probably, the most commonly used melting unit. The air furnace has in many cases been changed over to the use of pulverised fuel, and the Sesci and Bracklesberg rotary furnaces, fired with similar fuel, are finding a definite field of usefulness in manufacturing refined irons, and in providing metal for special castings. Oil-fired furnaces have been introduced, and in all these newer type furnaces, alloys can be more easily melted and properly distributed throughout the metal, owing to the high temperatures possible.

Sand Improvement

A great amount of research work has been carried out on sands for moulding and coremaking. Synthetic sands, too, have been developed, and have passed beyond the stage of experiment, thus affording much closer control. Particularly is this the case with repetition foundries, where, if the sand—and incidentally the metal as well—is not to specification, it is possible for a whole batch of waster castings to result. This has demanded that both sand and metal be subjected to standard tests at frequent intervals during the day.

Increased Metallurgical Knowledge

Probably the most important advances in the foundry industry can be attributed to the strides which have been made in metallurgical knowledge, which has enabled cast iron to find wider fields of application in the progressive world of to-day. In this connection, in addition to the work of investigators in the foundries themselves, tribute must be paid to the efforts of the various research associations, which have made available important reports and findings to the industry. The B.C.I.R.A., founded eleven or twelve years ago, and financed by the industry itself, is to be highly commended for the important researches undertaken, whilst the voluntary work of the Technical Committee of the Institute of British Foundrymen deserves special recognition. Scientific investigation such as this, and subsequent practical application, go hand in hand to ensure the success of any developments.

Referring to the question of the physical tests for cast iron, it is realised that the engineer must have some indication of the quality of the metal the foundryman uses for his castings, so that the engineer has imposed certain tests, such as tensile and transverse, which the foundryman must fulfil.

Much Higher Strengths Available

To be able to proceed with his design, the engineer must have a good idea of the strength and properties of the material he proposes to use,

and, if he refers to the older text books on cast iron, he would still probably find the figure of 8 to 11 tons per sq. in. tensile, which is correct for the ordinary types of castings previously mentioned. If he is familiar, however, with the B.E.S.A. Specification 321, he will find that the sizes of test-bars used are correlated to the various sections of castings, and higher values for tensile and transverse are given. The data officially available to the engineer are not yet up to date, unfortunately, and the Institute of British Foundrymen, which was responsible for the introduction of the B.E.S.A. Specification 321, is now reviewing it, and will soon have some recommendations to make regarding both the sizes of bars and the introduction of a grade for higher tests. With the advent of semi-steel, low-carbon irons, refined irons and alloy irons, tensile strengths of the order of 16 to 20 tons per sq. in. are regularly obtained, and in very special cases 25 to 30 tons per sq. in. can be reached. This has definitely put cast iron on a higher level, and made it of more interest to the engineer, who has perhaps regarded it in the past as a weak material. Other potential tests are being investigated, *e.g.*, shear, impact and fatigue, but these tests have certain intrinsic disadvantages, and have not as yet received universal approbation.

Competitive Materials

Developments have taken place, and are taking place all along the line, in the engineering world, no matter which particular branch is chosen for attention. Higher speeds, higher temperatures, greater stresses, and longer life, are the order of the day. The engineer has, therefore, demanded from the foundry, materials to suit modern requirements, and, at the same time, has been anxious to obtain castings that are sound, with a good appearance and closer to dimensions. The foundryman, no doubt, owes a great deal to the engineer and designer, in the ingenuity and enterprise they have displayed, resulting in increased demands from the foundry. In many instances this has pointed the way along which research and practice were to proceed, to say nothing, too, of the urge given to foundries by the competition from other sources, such as stampings, welded structures, and plastic products. Nor must it be overlooked that the foundries derived benefit from the intense competition experienced during the years of depression, demanding improved methods of production, and elimination of waste in the broad sense of the word.

The foundryman has given his attention to these special service conditions, and has been able to provide suitable materials for the engineer.

Wear Resistance Enhanced

With longer life in view, for instance, for the casting, the question of wear has been studied. Neath, in one of his Papers, states: "The utility of cast iron to withstand frictional wear under lubricated conditions has always been of great value to engineers, and where lubrication is not possible or desirable, it has been found that cast iron will give superior service life over many alloys. Take the modern internal combustion engine, for instance. The rapid development of the motor-car and the severe working conditions of the Diesel engine have revealed the fact that cast-iron cylinders, pistons and piston rings wear away in service more rapidly than desired, which is by no means a new problem, and so the development and use of cylinder liners made from heat-treated cast iron, with Brinell hardness values hitherto unthought of for cast iron, have resulted. Generally, nickel and chrome are associated together in the cast iron used in the production of hardened and tempered cylinder liners."

Hurst informs us that "in the oil-quenched condition, the hardness is raised to approximately 500 Brinell, and by tempering at 350 deg. C. the hardness is lowered slightly, but the ultimate strength is raised to a value substantially in excess of that of the material in the "as-cast" condition. Again Cr-Al cast irons can be nitrogen hardened by heating in anhydrous-ammonia gas, at a temperature of 500 deg. C., and the surface hardness, developed by this treatment, is from 900 to 1,100, measured by the Firth diamond hardness tester, and the depth of penetration, with a treatment of 80 hrs., is from 0.015 to 0.030 in. Such irons are being extensively used for cylinder liners."

Alloyed Irons Help Progress

Cylinders, cylinder heads and cylinder blocks are also made to-day of nickel-chrome and chromium cast irons, whilst some liners are cast with an iron containing 5 per cent. Ni.

Sometimes the necessity of obtaining a higher hardness value and uniformity of structure, to ensure an enhanced life, has to be met. This is evident, for example, in the machine-tool business, where rapid progress has been made in the last few years, in the design of machine tools, due principally to (1) shop production methods and (2) manufacture of special cutting tools. The advantages obtained by the use of cast iron are wearing qualities, accuracy and alignment, rigidity, and damping out of vibration. Brinell hardness numbers are sometimes demanded by the machine-tool makers on the various slides and working faces, and hardnesses of the value of 200 to 220 are frequently met with, and obtained by the founders. To obtain uniform hardness values of this order, either special irons may be used, or densening of the particular faces in the mould resorted to. It will be noticed, too, that with cast iron, a high finish can be obtained. Smaller parts connected with machine tools, such as gears, rollers, cams, etc., are heat-treated to give a hardness value of 400 Brinell.

Auto-body Builders Helped

Another application of improved cast iron as regards wearing qualities is for press dies, particularly in the motor trade, where such blocks are used for forming parts of the motor-car body, mudguards, etc. A hard, uniform structure is obtained with castings made from iron containing suitable percentages of nickel and chrome, alloyed together, where the customer is prepared to pay for the extra cost involved. On the other hand, much has been done to improve the unalloyed cast irons by ensuring close-grained structures. Smaller dies, for many purposes, are now being suitably heat-treated to give harder wearing surfaces.

Steel Rollers Demands Satisfied

The foundryman has also considered the question of wear, where temperature has to be taken into consideration. In the rolling mill industry, for example, where chilled and grain rolls of all descriptions are called upon to work under more severe conditions than hitherto, the question of producing a hard faced roll, with a strong interior, has indeed been a very perplexing problem. The hard face is necessary to ensure a better finish on the rolled product or to roll harder materials, so that the roll requires less frequent dressing, and gives increased tonnages rolled. The problem in procuring a hard surface was that the material which was used tended to produce a brittle roll. To-day, however, a hard-faced roll, with a strong interior, can be manufactured, and scleroscope figures of the order of 75 to 90 can be obtained with chilled rolls. With rolls for other industries, such as calendar rolls, paper rolls, seed rolls and rubber rolls, the founder has to supply them to definite Shore scleroscope hardness specifications. The rolling and kindred trades, in all their ramifications, have speeded up in operations, and have made demands on the foundryman which he has successfully met.

Abrasion Resistance Improved

The question of abrasion has received the attention of the foundryman, because it was recognised that ordinary cast iron wears away very quickly under certain conditions, and under the action of certain abrasive materials. It has been found that the addition of chromium or chromium and nickel to the metal has improved its resistance to abrasion, and this type of material has a fairly wide field of application. The engineer should, therefore, consult the foundries whenever he requires a casting to resist abrasion, stating the conditions of service. Beneficial results have been obtained in many plants such as gas works, coke-oven plant, and crushing machinery, by the use of alloy cast iron, and in some cases, by resorting to chilling the surface of the casting exposed to abrasion.

Growth Problem Solved

When ordinary cast iron is subjected to temperature, reduction of strength, growth, warping and scaling take place. Much consideration has been given to the question of heat resistance by the foundryman, and to-day he is able to offer irons to meet certain definite conditions of temperature service. During the last few years, for instance, the low-temperature carbonisation of coal has been developed successfully, and in this connection, it is a matter for congratulation to the foundries that the retorts are made of special cast iron, which has to withstand a continuous temperature of approximately 700 deg. C. An ordinary cast iron, with high silicon content and large graphite flakes, is definitely unsuitable, as the graphite flakes form inroads along which oxidation can take place, leading to the premature collapse of the material, but it is gratifying to know that the retorts of special iron give several years services.

Chemical Industry Benefits

The chemical industry has drawn on the resources of the founder, who has supplied suitable metal for certain castings which have been used up to a temperature as high as 850 deg. C. For higher temperatures, up to 950 deg. C., irons have been developed, such as "Silal" (2.5 per cent. T.C and 6 per cent. Si), "Nicrosilal" (with high Ni and Cr) and austenitic irons, which do not tend to scale and burn, and many applications are found for these types of iron, such as furnace castings, stoker links, firebars, retorts, etc.

Advance of Austenitic Irons

Another important matter of considerable interest to the foundryman and engineer alike is corrosion. Austenitic irons have been developed, which, in addition to showing a marked degree of corrosion resistance, are heat resisting, and with suitable compositions, are non-magnetic (10 per cent. Ni and 5 per cent. Mn). They also have certain valuable electrical properties, such as a high electrical resistance, coupled with a low temperature coefficient of resistance. "Niresist" is the trade name given to the austenitic alloy cast iron, containing 14 per cent. Ni, 5 per cent. Cu, 1 per cent. Mn and 6 per cent. Cr, and usually made by admixing suitable cast iron with Monel Metal. This iron has numerous applications, such as pumps for handling erosive and corrosive liquors, filter plates for caustic liquors, valves for chemical plants, and resistance grids. These austenitic irons have already been accepted by chemical, electrical and power engineers, as being a cheap material suited to many of the more specialised requirements.

Hydraulic Engineers' Demands Met

Reference should be made to hydraulic engineering castings, as the demand to-day is that they should withstand really enormous pressure, and due regard has to be directed towards obtaining an exceptionally close structure in the metal, and complete soundness and solidity of the castings. Improved metallurgical knowledge, the newer type of furnaces and the availability of refined and alloy irons have all enabled the foundryman to deal with the manufacture of all types of cylinders and rams to work under

these more severe conditions. Needless to say, all special irons demand special care and treatment in the foundries, and many alterations have had to be made in the usual moulding and casting processes to ensure success.

As the engineer himself requires recompensing for giving a better finished job, or a job to closer limits, so the foundryman should be paid for these higher-duty castings supplied to suit special service conditions, and because the engineer is requiring and obtaining an improved article. The buyer knows that he has to pay more for grinding a shaft, for instance, as against machining it only, so the same principle should be applied in the case of the improved cast iron.

How Engineers Can Help

Naturally, the engineer and designer can be of infinite help to the foundryman in the design of the castings, both from the point of view of simplifying production, with resultant reduction of costs, and by the use of uniform sections of metal, where possible, to minimise the foundryman's difficulties in supplying sound castings. The question of thick and thin sections of metal, juxtaposed in the casting, is perhaps not quite the bogey it was some years ago, but it still exists to trouble the foundryman. Research is proceeding with the idea of producing a particularly close-grained iron, showing as little sensitiveness as possible to variation of section, but, of course, it will require trying out under practical working conditions.

The question of cambering and warping is a phenomenon over which the foundryman really has very little definite control, and experience, in the main, is the only guide. If the design of the casting be simplified, however, and the sections of metal be fairly uniform, the foundryman is better able to form some idea as to how the casting will behave in manufacture.

It has only been possible to indicate certain of the advances made in the foundry, and it is regretted that it is impossible to deal with the subject more fully, but if foundrymen would periodically, and systematically, direct the attention of the engineer to the development of cast iron as an engineering material, its higher specifications and its potentialities for service in the various fields, and also put before him regularly the important features of foundry practice and products, it is felt that it would be worth while. After all, the foundry is the foundation stone of engineering, and co-operation between the engineer and foundryman should always be encouraged, and a free interchange of ideas and opinions is bound to react to the welfare of both.

In conclusion, it is necessary for all foundrymen and the practical man especially, to acquire as much technical knowledge as possible. Facilities for education and for collection and distribution of information exist to-day such as have never been known in the past.

Let us, too, ever keep before us the objects of this Institute. Let us endeavour to break down those out-of-date barriers of conservatism, be ready at all times to exchange our experiences, to discuss our difficulties, and to give expression to our views. In this way shall we be striving to follow the aims of the Institute and assist the progress of an industry which is probably the most fascinating of all.

Vote of Thanks

MR. C. D. POLLARD, proposing the thanks of the meeting to Mr. Roxburgh, said the resolution should be not only one of thanks but also of congratulation. If any evidence were necessary that Mr. Roxburgh was suitable to be their President, he had supplied that evidence in the review which he had just given them. For some time, he had given them a very good lead in their discussions. Some of them had known Mr. Roxburgh's father for a good many years, and if he had a regret that night it was that Mr. Roxburgh, Sen., was not present to see his son take over the Presidential duties. The success of a Branch did not depend merely on the chairman. It was for all the members to give him every support they possibly could, and he hoped that support would be accorded.

MR. J. R. HYDE, in seconding the resolution, emphasised that they were all in the position of having to justify their art in the eyes of the engineer. Mr. Roxburgh was a real and capable leader, and he (the speaker) could see that a very interesting session was promised, and that Mr. Roxburgh would direct the arguments to the great advantage of practical men.

The resolution was carried with applause.

MR. ROXBURGH returned thanks for the appreciative remarks that had been made, and said he had felt for many years that the interest displayed in the Institute and its activities in Sheffield was really very small for a city of such a size. He had been at most of the lectures, and on some occasions there had only been about twelve people present. He hoped that during the coming session they would strive not only to increase the membership but to get present members to come along in better numbers than had been the case hitherto. The Council endeavoured to prepare a very attractive programme, and the meetings were made as informal as possible, and they appealed to the members to attend and support them.

The SECRETARY announced that on October 31 the Sheffield Branch and the East Midlands Branch would have a joint meeting at Derby, visiting the works of International Combustion, Limited. On November 5 the Sheffield Branch would hold a Short-Paper Competition. He appealed to members to send in Papers, remarking that they would be read by members of the Council, and the writers' names need not be divulged if they wished to remain anonymous. There would be prizes of two guineas and half-a-guinea, given by the President.

The meeting was followed by a smoking concert, at which the artistes were Mr. Ellis Green (tenor), Mr. Charlie Ellis (entertainer) and Miss Mary Helliwell (accompanist).

Publication Received

The Works of International Combustion, Limited, Derby. It is very much appreciated by customers when large engineering works prepare for distribution a technical description of their works. While this has often been done, it has seldom been more satisfactorily accomplished than by this concern. We have had the privilege of describing the foundry and the new mechanised continuous casting plant in our columns and we feel that the possession of this brochure splendidly rounds off published work. Obviously a better balance is given and the foundry occupies in it a legitimate and important place, but other departments also receive adequate description and illustration. We strongly advise readers who have an interest in the lay-out of modern works and foundry departments to write to the London office of International Combustion, Limited, Aldwych House, Aldwych, London, W.C.2, for a copy of this particular publication.

Catalogue Received

Compressed-Air Driven Tools. Of considerable interest to foundrymen is a new catalogue of compressed-air actuated tools recently issued by Dollery & Palmer (F.M.A.), Limited, of 26/27, Bush Lane, Cannon Street, London, E.C.4. The description of fettling hammers, pneumatic core-ejecting hammers, powder screens (for vitreous enamelling baths), drills, grinding and polishing machines will be especially interesting. The last few pages—there are sixteen in all—are devoted to compressed-air plants.

Second Report of the Steel Castings Research Committee

(*Continued from page* 293.)

The influence of orientation on the reduction of area was more pronounced. In electric-furnace steels the reduction of area diminished continuously from 750 to 1,200 deg. C. From 1,200 to 1,350 deg. C. it was relatively great perpendicularly to the direction of crystallisation and almost nil in that direction; above 1,300 deg. C. it was nil. The variations were different for other steels, as the curves reproduced in Fig. 6 indicate. For basic open-hearth steel the reduction of area increased from 750 deg. C. upwards, high values were obtained over a wider temperature range and orientation of the crystals gave rise to no difference. The acid open-hearth steels had a similar high capacity for deformation with no difference in the two perpendicular directions. The Bessemer steels showed a greater directional effect.

In discussing the results of their experiments, Piwowarsky, Božić and Söhnchen suggest that the tendency to equality above 1,000 deg. C. is due to the disappearance of the casting structure through the action of diffusion and recrystallisation during deformation. The increase in the reduction of area is held to be due to increased plasticity of the material, especially of the grain boundaries, and the fall at higher temperatures to the progressive decrease in strength which continues to operate until the fracture occurs under so low a load that the material will not hold together while deformation occurs. Between 1,000 deg. C. and the melting point the region of high reduction of area differs for different steels. The range of temperature between increase and decrease of capacity for deformation may be narrow or wide according to the material, but although this is probably due to grain boundary differences, the chemical constituents which narrow the range are not clearly revealed in these experiments. The authors, however, presume that the open-hearth steels, especially basic, have the highest capacity for deformation at temperatures not far removed from their freezing points, and give preference to them when looking for a steel which will not tear. They admit, however, that it will be necessary to ascertain, by the study of a large number of casts, whether the manner in which the steel behaves in this "critical zone" depends on the method of manufacture.

(*To be continued.*)

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The Effect of Non-Metallic Inclusions on the Graphite Size of Grey Cast Iron

By A. L. NORBURY, D.Sc., and E. MORGAN, M.Sc. (British Cast Iron Research Association, Birmingham)

(*Concluded from page 274.*)

Differences in Fracture Obtained on Crucible and Cupola Melting

Certain of the titanium-containing pig-irons gave an almost completely refined fracture on a 3-in. bar, simply on remelting in the crucible with 10 per cent. of steel. Consequently, such charges were melted in the cupola to see if equally fine graphite casts could be obtained. The cupola casts were, however, usually much coarser and often almost completely coarsened, even when carbon dioxide was bubbled through the molten metal in the ladle for 2, 4, and 8 min. The strengths of 3-in. test bars cast from these cupola melts were in some cases only about two-thirds of those of metal of the same analysis made from the same charge melted in the crucible. These cupola casts also gave only slightly less coarse fractures on remelting in the crucible and treating with carbon dioxide, and not completely fine fractures on remelting and treating with 2 per cent. of titanium and carbon dioxide for 2 min., although further treatment refined them completely. The analyses did not account for such differences. In some cases they were almost identical, although the tendency was for the cupola melts to be higher in carbon and lower in silicon and manganese. The possibility that sulphur pick-up might account for such differences was also investigated, but additions of over 0.1 per cent. of sulphur to the crucible melts did not produce any appreciable coarsening.

In some cases the coarsening of the fracture on cupola-melting was much less than in others, and fairly fine fractures containing a large amount of fine graphite in the microstructure were obtained, especially on the thinner sections. It was, however, already known that charges of titanium-bearing pig-irons could give fine-fractured casts under certain conditions of cupola-melting, but the nature of the conditions required to give the fine graphite was not understood.

Crucible Melts over Coke

The same charges were consequently melted in the crucible over coke, coke ash, limestone, cupola slag, and sand, with and without air blown through during melting, in an attempt to imitate cupola conditions in a crucible melt. Coke had a definite coarsening action, but this was partly due to carbon pick-up, and in some melts in which steel was subsequently dissolved in the melt to offset this, little coarsening action was obtained. Coke did, however, appear to have a coarsening action under certain conditions, and it was thought that this might be due to inclusions entering the metal, owing to its dissolving coke containing very finely divided coke ash. Moreover, the addition of sodium carbonate to the coke appeared to reduce its coarsening action in such crucible melts.

The effect of coke, however, was not further investigated, since it was found that the same charges were also coarsened by melting in oil-fired and pulverised-fuel-fired rotary furnaces. This showed that coke ash was probably not the main cause of the coarsening of cupola metal.

Oxidation Experiments on Crucible Melts

Since considerable losses of silicon and manganese occurred in most of the cupola and rotary-furnace melts, and since these did not occur in the crucible melts, it was decided to investigate the effect of oxidation on crucible melts more thoroughly. Charges of the same titanium-bearing pig-irons were again used in these experiments, since they gave an almost completely fine fracture on a 3-in. bar, simply on remelting in the crucible. It was thought that inclusions formed by oxidation at a low temperature might be different and have a different effect from those formed by oxidation in the molten metal. Consequently carbon dioxide, or air, was blown into the crucible or metal before, during and after melting; in other cases iron oxide scale was stirred in after melting, but although appreciable losses of silicon, manganese and titanium were produced (*e.g.*, Si 2.13 per cent. → 1.68 per cent., Mn 1.36 per cent. → 1.10 per cent., Ti 0.20 per cent. → 0.15 per cent.), no coarsening of the graphite was obtained, the 3-in. bars having almost completely refined graphite structures after such treatments.

Reduction Experiments on Crucible Melts

The effect of reducing conditions, which now appeared to be the most likely alternative, was then further investigated. The possibility of these being the cause of the difference between the crucible and cupola melts had been thought unlikely, since it was assumed that cupola-melting was more oxidising than crucible-melting on account of the higher manganese and silicon losses. Moreover, the general conclusions from previous experiments had been that although bubbling hydrogen through the melt, usually for 2 min., had a coarsening action, this was removed by bubbling carbon dioxide through the melt. This conclusion had, however, been obtained on melts probably containing few inclusions, such as silicates, and in which the titanium was added and hydrogen bubbled through before the titanium had been oxidised.

When the effect of bubbling hydrogen for two minutes was tried on the same charges as those used in the above oxidation experiments, in which the titanium was probably oxidised, owing to oxidation during melting, before passing the hydrogen, it was found that coarsening was produced and that this was still produced when the melt was subsequently stewed for ten minutes and carbon dioxide bubbled through for two minutes, the titanium content of the cast having fallen considerably. Bubbling hydrogen for four minutes instead of two produced greater coarsening, which was not removed by remelting and bubbling carbon dioxide through. Bubbling carbon dioxide through for two minutes before bubbling hydrogen for two minutes reduced the coarsening, and the addition of 2 per cent. of ferric oxide instead of the carbon dioxide reduced it still more, but bubbling hydrogen for longer periods after these oxidising treatments produced more complete coarsening than when the melt had not been previously oxidised in this way. Still further and almost complete coarsening and loss of titanium resulted by giving the melt reducing, oxidising, reducing, then oxidising treatments. This treatment consequently caused coarsening similar to that produced by cupola melting.

Melts of hematite pig-iron plus 10 per cent. of steel were then subjected to oxidation followed by reduction treatments as above, and then 2 per cent. ferro-silicon-titanium additions were made and carbon dioxide was bubbled through for two minutes. It was found that only a little refining was obtained and that the titanium yield was much lower than that obtained on adding it to the untreated melt or to a melt treated under oxidising or reducing conditions alone. Consequently, in this respect also, oxidising and reducing conditions made crucible metal similar to cupola metal.

Discussion of Results

Considering the above oxidation plus reduction experiments first, since these produced coarsening and low titanium yields on crucible metal and made it similar in these respects to cupola metal, and since coarsening had also been obtained by melting over coke, the probability appears to be that the coarsening effect on cupola melting is due to the coke having a reducing effect on inclusions previously formed by oxidation. In the cupola the reducing conditions may only occur locally at metal-coke surfaces as the molten metal drips over the coke. That intimate contact with carbon or some compound containing carbon does occur is shown by the increased carbon content usually obtained. Some reduction may also be due to hydrocarbons in the coke, some of which are not decomposed until high temperatures are reached, and to steam, of which there are various sources.

Moreover, the finest graphite structure (almost completely fine on a 3-in. bar) so far produced from a titanium-containing charge melted in the cupola had been obtained by rapid, rather oxidising melting in a very small, 12-in. dia. cupolette. The silicon fell from 1.86 to 1.34 per cent., the manganese from 0.88 to 0.57 per cent., and the titanium from 0.20 to 0.13 per cent. The carbon only increased from 2.83 to 2.92 per cent. The same charge melted slowly in the same cupolette gave a much coarser fracture. That reducing conditions may also be present in rotary furnaces, in certain parts of the flame and under certain conditions, is also evident.

It is suggested that the reducing conditions reduce FeO and make the inclusions richer in SiO_2 and TiO_2 and of higher melting point, as discussed in Part I.

The difficulty of refining ladles of cupola metal by adding titanium and oxidising, also appears to be due to the presence in the metal of the above inclusions, with which the titanium inclusions combine and float up out of the melt. When such cupola metal is remelted in the crucible, the number of these inclusions is reduced by coagulation, flotation, etc., and the metal is easier to refine, but refining probably only occurs after the original inclusions in the metal have been fluxed out by the titanium inclusions generated in the melt. It is difficult to refine ladles of cupola metal in this way, owing to the temperature falling too low before the larger amount of titanium required can be dissolved.

Moreover, if the metal contains a large quantity of slag inclusions, these inclusions coat the titanium alloy and prevent it from dissolving. The hematite pig-iron used in the crucible melts was comparatively easily refined by the titanium and carbon-dioxide treatment, and appeared, under the microscope, to contain very few inclusions, apart from traces of MnS (S 0.03 per cent.). The other pig-irons tested were also, generally speaking, very much easier to refine than the average cupola metal, and appeared to be much freer from inclusions. It seems probable that pig-irons (since SiO_2 and TiO_2 are reduced and dissolve in the metal in certain parts of the blast-furnace) are, at certain stages in their descent of the furnace, practically free from oxidised inclusions, and that the few that may be formed result from oxidation lower down in the furnace or during tapping. In the pig analysed by Shimmer (*loc. cit.*) the titanium was entirely in the form of TiC, and since it is probably more easily oxidised than silicon and manganese, such a pig-iron should be almost free from inclusions, apart from MnS.

If oxidised inclusions are absent from pig-irons, it is suggested, since manganese sulphide would be the only inclusion present, that the amount

of manganese sulphide present would, in hypo-eutectic compositions, determine the coarseness of the fracture.[15] Some hold that it is the determining factor, but in most cases it may be that this alteration in fracture with increased sulphur content is really due to a simultaneous fall in carbon content which occurs when the furnace is working colder and the sulphur content increases. If, however, titanium is also present, it would, upon oxidation, become the determining factor, since it would combine with the manganese sulphide inclusions and give a fine graphite structure. That it is the determining factor on remelting, during which oxidation occurs, is shown by the above results.

Conclusion

Further investigation on this and other points is being continued. The results up to date, however, have been reported at this stage in view of the extent of the problems involved.

The charges, melting conditions, and treatments which produce the finest and the coarsest graphite structures are being worked out more fully. The separation, analysis, and determination of the freezing points of the inclusions formed in typical melts are also being carried out. A number of results on the effects of the fine and the coarse graphite structure on the mechanical and other properties have already been obtained, but further investigation has been largely deferred until their production under commercial conditions has been satisfactorily worked out.

The authors thank the Council of the British Cast Iron Research Association for permission to publish the present results.

APPENDIX 1

Experiments on the Effects of Gases on Cast Iron

The following experiments were made on ¼-lb. melts of Swedish white iron (T.C 3.7 per cent., Si 0.2 per cent., Mn 0.03 per cent., S 0.03 per cent., P 0.03 per cent.) melted in small fireclay crucibles in a Silit electric furnace, working at about 1,350 deg. C.

When the white iron was melted without treatment and the crucible was taken out of the furnace and cooled in air, a continuous shower of sparks was shot up into the air from the top surface of the metal during cooling and until solidification occurred. These sparks ceased when nitrogen or hydrogen was blown on to the top surface of the metal, and were accentuated by blowing air or oxygen on. The resulting ingots were honeycombed with blow-holes when the reaction took place, but were free from blow-holes when the ingots were solidified in an atmosphere of nitrogen. The blow-holes were bright and only slightly discoloured when completely enclosed by solid metal. When channels connected them to the outside surface of the ingot, they were discoloured and black. Stirring in iron oxide made the metal froth up and caused similar unsoundness. When ½ per cent. of silicon or manganese was dissolved in the metal, no sparks were emitted. The same is observed in the foundry, since low-silicon irons spark much more than higher-silicon irons.

The sparks and blow-holes were evidently due to oxygen in the air reacting with carbon in the metal, and it seems likely that the intermediate formation of iron oxide occurred. It will be noted that the white iron is similar in composition—apart from its carbon content—to an unkilled steel, and that the above reactions are very similar to those occurring in steelmaking.

Although the ½ per cent. silicon and manganese additions prevented sparks from being emitted during solidification, even with 5 per cent. additions of these elements the slag film on the top surface of the metal always frothed during solidification, showing that gas was evolved either from the metal or from the oxidation of carbon at the surface of the metal.

Bubbling hydrogen into melts of cast iron was found to produce large numbers of blow-holes in the solidified metal. These were very marked when the rate of cooling was such that the gas was just trapped by the formation of a solid outer shell of metal, and the cooling of the interior was sufficiently slow to allow the gas to form blow-holes. If the rate of cooling before solidification was very slow, the gas tended to free itself from the molten metal and not to form blow-holes. On the other hand, if it were very rapid the gas appeared to be retained in some enforced compressed state, and did not form visible blow-holes. Blow-hole formation due to hydrogen was specially marked in 15 per cent. silicon, 0.7 per cent. total-carbon cast iron. When hydrogen was bubbled for two minutes and the metal was then cast, the gas evolution caused the metal to rise in the pipe and give a cauliflower top. The same metal gave a deep pipe when melted without this gas treatment. Hydrogen produced blow-holes in all compositions of cast iron, but they were more marked in low-total-carbon irons, such as the above, in which a solid outer shell of metal is more rapidly formed on casting. It was found that bubbling hydrogen through for about two minutes was sufficient to produce the maximum effect and that bubbling nitrogen through for about two minutes almost completely removed the hydrogen. Similarly, bubbling carbon dioxide or air through removed the hydrogen, and allowing the metal to stew in contact with air produced the same effect, although more slowly. Contact with air during cooling and solidification was also found to be enough to eliminate a considerable quantity of the hydrogen (and this elimination was more rapid in low-silicon, low-manganese irons), since greater unsoundness was produced by cooling a hydrogen-treated melt in an atmosphere of hydrogen.

Bubbling steam into molten cast iron produced the same unsoundness as hydrogen, the steam being apparently reduced. The same unsoundness and cauliflower-topped runners can be produced when steam bubbles through the molten metal, due to the use of a damp sand ladle. When blow-holes are found in cast iron, generally near the surface of a casting, they are probably due to moisture in the moulding sand reacting and hydrogen dissolving in the metal. Such blow-holes have been found to a very marked extent in grey-iron test bars containing 5 per cent. of manganese and upwards, and it may be that steam is more rapidly reduced to hydrogen in irons containing easily oxidised elements such as manganese.

Nitrogen bubbled through various compositions was not found to produce any visible unsoundness; on the contrary, it removed unsoundness produced by other gases, as stated above.

It will be noted that the above experiments suggest the possibility of making rimming steel in any composition of steel, even those high in silicon, by bubbling hydrogen into the melt, also the possibility of deoxidising steel with hydrogen and then removing the latter by blowing nitrogen or some other non-oxidising gas through and cooling in a non-oxidising atmosphere. Steel made in this way should be almost free from the inclusions normally produced by deoxidisers.

The above experiments were actually made in 1933, and are in agreement with investigations carried out by Edwards and his collaborators[16] on the effects of oxygen and carbon, and those of Swinden and Stevenson[17] on the effects of hydrogen, nitrogen, etc., on the blow-holes in steel ingots.

APPENDIX 2

The Freezing Points of Iron-Carbon-Silicon Eutectic Alloys

During the course of the main investigation on graphite formation, a number of cooling curves were taken on cast irons of different silicon contents, treated with titanium and carbon dioxide to give the fine graphite structure, or produced from synthetic melts of Swedish iron and 40 per cent. ferro-silicon to give the coarse graphite structure, to ascertain if the latter solidified at a higher temperature than the former. The results showed that this was the case, and also that the freezing point of the eutectic in hypoeutectic compositions varied with the silicon content, the carbon content, and the rate of cooling. It was, however, not possible at the time to carry out the large number of determinations required to complete the investigation.

In the case of hypereutectic compositions, the results were much simpler. The eutectic freezing points of these alloys up to about 10 per cent. silicon were found to depend only on the silicon content. The alloys were made from Swedish white iron and 40 per cent. ferro-silicon, and were melted under wood charcoal. One-half per cent. of 80 per cent. ferro-manganese was added to each alloy to neutralise the 0.03 per cent. of sulphur present, since even this amount of sulphur lowers the freezing point slightly, and

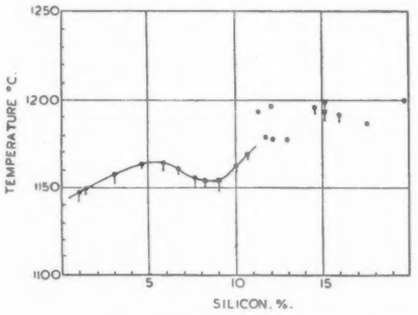

FIG. 1.—THE FREEZING POINTS OF IRON-CARBON-SILICON EUTECTIC ALLOYS. THE DOUBLE POINTS INDICATE THE EXTENT OF THE RECALESCENCE.

manganese even in much larger quantities has little effect. The results are shown in Fig. 1, the double points indicating the extent of the recalescence. It will be seen that increasing silicon content does not cause a linear increase in the freezing point as is usually shown, but that it causes it to rise and then fall and then rise again. The fall may be due to the deposition of progressively increasing amounts of δ-iron instead of γ-iron, which occurs over about the same range of composition. Above 10 per cent. silicon the results are erratic, and further investigation is required. It may be that the complication found by Houghton and Becker[18] in the iron-silicon system between 12 per cent. and 20 per cent. silicon affects the freezing points in this range. The alloys contained certain amounts of oxidised silicon, owing to their having been melted in air, but it is not thought that this affected the results appreciably, and it is very difficult to estimate silica in high-silicon compositions, which are themselves very resistant to solvents. It is probable that the effect of silicon on the carbon content of the eutectic is also similarly complicated, and is not to lower it linearly as is usually shown.

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15 The fracture of pig-iron is discussed in a recent Paper by the uthors, FOUNDRY TRADE JOURNAL, 1936, vol. 54 p. 453.

16 C. A. Edwards and H. N. Jones, Fifth Report on the Heterogeneity of Steel Ingots, Section V. "Iron and Steel Institute Special Report," No. 4, 1933; C. A. Edwards, R. Higgins, M. Alexander, and D. G. Davies, Sixth Report on the Heterogeneity of Steel Ingots, Section XI. "Iron and Steel Institute Special Report," No. 9, 1935.

17 T. Swinden and W. W. Stevenson, Sixth Report on the Heterogeneity of Steel Ingots, Section VIII. "Iron and Steel Institute Special Report," No. 9, 1935.

18 J. L. Houghton and M. L. Becker, "Journal of the Iron and Steel Institute," 1930, No. I, p. 322.

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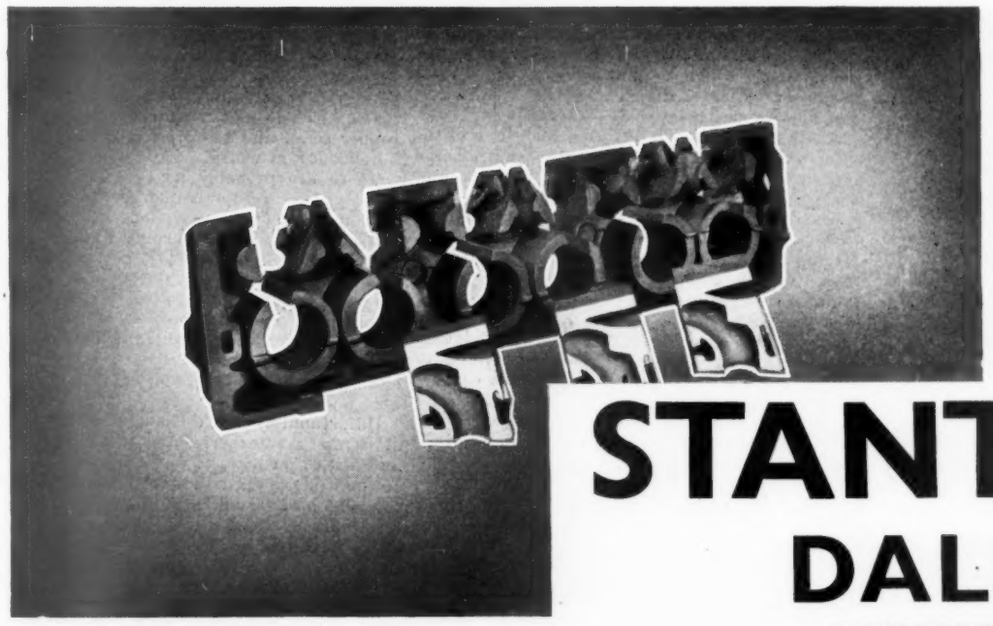

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The Derby Convention

MR. BUNTING'S PRESIDENTIAL ADDRESS

At the opening meeting of the winter session of the East Midlands Branch of the Institute of British Foundrymen, held at the Technical College, Derby, on September 26, Mr. H. Bunting, the new Branch-President, was inducted to the chair by Mr. A. E. Peace.

In the course of his Presidential Address, MR. BUNTING said: I should like to draw attention to what is before us in the very near future, that is the 1937 Convention, which is to be held in this area. I would appeal to the members to render every possible assistance to the Council in the heavy task which confronts them, and I would appeal especially for help to the secretary, on whom the bulk of the work will fall. One thing in which all can help is in the introduction of new members. The Convention period is always a good recruiting time, and during the last Convention period in this area we increased our membership by 60 per cent. With trade in a very much better state now than it was then, we should get 100 per cent. increase.

I want to stress the new item which the Council are putting forward for this session, which it is hoped will stimulate the discussions. A prize will be awarded at the end of the session to the member who obtains the most points in the discussions. This award is being made in the hopes that those members who usually abstain from taking part in the discussions will begin to participate.

Technical Training

I cannot leave the affairs of our Branch without a word on technical training from the foundryman's position. Progress has been made during the past few years in the provision of facilities for technical training, both in the recently-formed foundry schools and technical colleges. Whilst the foundry schools will only have a few of the best men, the technical colleges will have to provide for the majority of the foundrymen of the future, and in this respect the lack of knowledge the youth of seventeen has on certain subjects is deplorable. In mathematics the technical colleges will do their part, but I think the youth leaving school should have a better knowledge of spelling than he has.

Industrial Development

It has become a habit to date all things as from 1918, and to regard everything which happened up to 1914, and the outbreak of war, as belonging to a past economic era, which has no bearing on the present. Certainly commerce, finance and industry have developed in such a manner during the past twenty years that they bear but slight resemblance to things as they were prior to the war; but I am inclined to ascribe the change in conditions to new economic factors which have arisen, and which may be the outcome of legislation following the war, rather than due to the war itself.

In late years we have seen the overthrow of the ideas of the protagonists of big business, who previously postulated a state wherein all the smaller enterprises and businesses would be merged into gigantic trusts, whose huge accumulated capitals would be brought to bear on the smaller fry who declined to be absorbed. Rationalisation was the label given to the operations of those merger financiers who endeavoured, and for a time succeeded, in inducing the investor to believe that his capital was safe only if invested in an industrial concern capitalised at many millions.

During the war period we had grown so accustomed to thinking in terms of "millions of men" and "tens of millions of money" that in peace time considerable effort was required to regain normal conditions, and for a long time things were looked at as through magnifying glasses, which distorted the true perspective of things. During the war many concerns were induced to multiply their works, the number of their employees and their output, to meet the incessant demand for war material. When peace was declared there were huge factories in various parts of the country, just as there were in other countries, so that when our factories sought to turn to peace-time pursuits, they were checkmated by the competition from other countries, where the standard of living, etc., was lower. The result was that the companies which had been engaged in making war material were faced with empty order books. For a short period there were boom conditions in British manufactures, but only until the depleted home stocks had been replenished.

During the past few years manufacturers, both large and small, have abandoned the policy of only selling their products to the middleman. They reasoned, and that correctly, that if the big concern were to be served by them direct, there was no reason why the smaller concern should any longer be forced to deal with them through other intermediaries. A further factor which contributed to the success of this new policy was that, after the war, the old basis of credit was annihilated.

Future Lines of Development

The trend of future British industrial development will unquestionably lie in the direction of nursing small enterprises, and providing them with the capital means so that they can develop into large enterprises, and to accomplish this on modern financial lines which have little if anything in common with the orthodox methods of the past. I think we have said good-bye, and not before it was time, to the old hide-bound orthodox systems, which were devised for the express purpose of keeping the small business down and allowing the big concern to get even bigger.

Another thing which has been relegated to the past, and which I believe will not again emerge into prominence in our time, is the system of rationalisation, which has been exploded as a fallacy by the failure, which latterly has been pronounced, of the titanic institutions to keep getting bigger and ever more profitable. It has been demonstrated that there is a limit to the profitable development of any manufacturing concern.

In manufacture, a medium-sized producing plant's requirements and possibilities require to be visualised by one man, who must be conversant not only with the demand likely to be made on his concern for finished goods, but also with the raw material markets. In general, he must carry out so many duties in the course of each working day that, when a business grows beyond a certain size, it becomes unwieldy and incapable of being properly controlled by one manager, who is subject to human limitations. In large concerns the idea of team-work in this connection has been tried, but where the responsibility for weighty decisions is divided, the result is akin to a house divided against itself, and stultification and often disaster is the outcome.

A vote of thanks was accorded Mr. Bunting on the motion of MR. W. H. SMITH, seconded by MR. W. T. EVANS, and supported by Mr. Walter (secretary of the Lincoln Section).

PARTICULARS have been published recently for information only of an issue of £100,000 4 per cent. debenture stock of Ransomes & Rapier, Limited, engineers and ironfounders, of Ipswich. The issue is made for the purpose of providing funds for the repayment of 5 per cent. first mortgage debentures and 7 per cent. second mortgage debentures.

The Scrap Metal Situation

By "ONLOOKER"

Since the war ended and left the market with a legacy of non-ferrous scrap which looked ominous, but was actually absorbed without much trouble, the scrap metal trade has suffered many changes in fortune.

As often happens, a high level for virgin metals has found the scrap market well supplied with raw material, for dismantling has been a paying proposition and owners have not hesitated to take advantage of lucrative returns on what they were holding. On the other hand when values have been low, and for the past five years they have been little else, it has been very difficult to achieve anything like a good turnover in old metals, while when copper fell to 5 cents, business in the lower grades of copper-bearing material ceased almost entirely.

It was during this period, when the margin between the mixing value of scrap and that of virgin metals became so narrow, that consumers turned to copper and spelter and to a great extent lost the habit of melting scrap. To-day margins are very much better than they were and the more discriminating buyers are taking advantage of this fact in framing their purchasing policy.

Fashions come and go in scrap as in everything else, and the years see certain grades which at one time were prime favourites relegated to second or third place in consumers' favour. The ebb and flow of Continental demand makes all the difference to our market in this country, for, to quote only one example, French or German buying of brass swarf lifts the quotation quite appreciably, since, generally speaking, foreign buyers are prepared to offer better prices than users in this country. There was a time some two or three years ago when Germany was taking very considerable tonnages of copper scrap from us and the price was relatively high in consequence, but this demand has rather tailed off, and to-day it is noticeable that the margin between the market value of heavy copper scrap and the price of electro is showing a tendency to widen.

There are probably no excessive tonnages of this type of scrap available, but with buyers rather reticent we may see the gap become wider yet before the surplus which appears to be on hand is reduced. The makers of extruded brass rods and sections, on the other hand, are very busy indeed, and there is an excellent demand for suitable brass scrap which dealers find it not too easy to satisfy. The increase in manufacturing activity ought to bring more process scrap on to the market, but of this there is little indication.

Unfortunately the difficulties which importers of scrap are experiencing with the Customs authorities do not get any less, and as a result of the arbitrary attitude adopted by the officials it has become very difficult to negotiate purchases from abroad. This is a pity, for at a time when many foundries are crying out for raw material it is unfortunate that obstacles should be placed in the way of supplies. As already mentioned consumers are showing rather more interest in old metals owing to better margins, and should they really begin to buy scrap in real earnest then there would not be any too much to go round, unless of course unexpected reserves should be disclosed. This question of the old metal reservoir is one of perennial interest to all connected with the trade, and it is far from easy to estimate at any given time what tonnage is available under this head. It is doubtful if in this country there is any considerable quantity of scrap out of sight, but it is generally supposed that France still has a very fair reserve of "war scrap" in government hands. On the whole scrap metal seems to be a pretty safe investment at ruling prices.

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The Week's News in Brief

Trade Talk

PREMISES HAVE BEEN TAKEN in City Road, Derby, for a malleable iron foundry.

RUSTON & HORNSBY, LIMITED, Lincoln, have given six months' notice to redeem on April 1, 1937, the entire outstanding £60,000 5½ per cent. mortgage debenture stock at 110 per cent.

THE NATIONAL UNION OF FOUNDRY WORKERS have withdrawn the ban on overtime in Aberdeen, the employers having agreed to pay the national minimum rate of £3 8s. 10½d. a week.

ASSOCIATED ELECTRICAL INDUSTRIES, LIMITED, proposes that all the ordinary and preference shares issued and paid up, but not converted into stock, shall be converted into stock forthwith.

AN EXPLOSION which damaged a steel furnace in course of erection at Dorman, Long & Company, Limited's, works at South Bank, near Middlesbrough, killed two workmen and injured eleven others.

GUARANTEES FOR £36,000 for the organising of the Empire Exhibition to be held in Glasgow in 1938 include £10,000 from G. & J. Weir, Limited; £10,000 from Imperial Chemical Industries, Limited; and £5,000 from British Oxygen Company, Limited.

AN ARGENTINE SUGAR FIRM has placed orders for three 13½ ft. and one 11½ ft. vacuum pans for sugar boiling with Mirrlees Watson Company, Limited, Glasgow. The Glasgow firm also have an order for a plant capable of crushing 1,000 tons of cane per day for the Government of the Nizam.

THE EARL OF CRAWFORD AND BALCARRES opened a novel coal showroom at 38, Deansgate, Manchester, on October 6. After the opening ceremony Lord Crawford was entertained at a luncheon at the Hotel Victoria, presided over by Mr. R. A. Burrows, chairman of Lancashire Associated Collieries.

A FIRE WHICH OCCURRED at the works of the Hammond Lane Foundry Company, Limited, ironfounders, of Dublin, caused extensive damage to the pattern loft, paint and fitting shops, the smithy, and a portion of the warehouse. Patterns, accumulated over a period of thirty years, were lost in the fire.

AT A MEETING of the Welsh Engineers' and Founders' Conciliation Board in Swansea, last week, an application from the workmen that payment for 47 hours be made on each of the three shifts was favourably considered. It is understood that the employers indicated their agreement, provided that there shall be an acceptance of new wording in certain clauses of the existing agreement.

THE PARTNERSHIP between Messrs. G. D. B. Birch and C. F. Dingley, carrying on business as brassfounders, at Furnbras Works, Kings Road, Tyseley, Birmingham, under the style of Birch & Company, and/or G. B. Birch Company, was dissolved as from December 31, 1935, by mutual consent. Debts will be received and paid by H. H. Sherwood & Company, York House, Great Charles Street, Birmingham, chartered accountants.

ALTERATIONS AND EXTENSIONS at the South Wales Steelworks, Llanelly, which have been decided upon by Richard Thomas & Company, Limited, involve the closing down of the foundry at the works, and notices have been issued to approximately 100 men terminating contracts on October 31. It is understood that the foundry premises are to be demolished in order to make room for the extension of the bar mill attached to the South Wales Steelworks, where important developments have taken place recently.

THE DARLINGTON FORGE, LIMITED, supplied all the principal hull castings for the "Queen Mary," but the company is too busy to undertake similar work for the sister ship shortly to be built on the Clyde. Mr. W. O. Pugh, superintendent of the Forge, in an official statement, says: "Our commitments for steel castings, mostly for our associated companies, will fully occupy our capacity for many months and in the circumstances it was impossible for us to undertake the supply of the main castings in the time required. We were asked to accept the contract, but reluctantly had to decline it. We were, however, able to accept a contract for four large stern tubes and these will be manufactured at Darlington." The hull castings are being made by William Beardmore & Company, Limited, at Parkhead, Glasgow.

COL. W. TOZER was installed as the 303rd Master Cutler at Sheffield on October 7, and was invested with the chain of office by the retiring Master (Sir Samuel Roberts, Bt.). In his address, Col. Tozer mentioned that his grandfather, Alderman Tozer, was Master Cutler in 1875 and in 1876, and was also Mayor of Sheffield in 1880. Col. Tozer added that the name of his family had been closely associated with the steel trade of Sheffield for the past 60 years. He said that steel production in Sheffield had broken all records. In 1913 nearly 900,000 tons was produced, a record up to that date. A new record was created in 1929, showing an increase of 33 per cent., which was again exceeded last year. Up to the present date there was every indication that the production of the current year might be 25 per cent. higher still, and should reach, in 1936, in the Sheffield district, a total of no less than 1,500,000 tons.

Company Reports

Herbert Morris, Limited.—Profit, £119,505; directors' fees, depreciation, dividend on preference shares and interim dividend already paid on the ordinary shares, £47,698; brought in, £27,507; final dividend of 12½ per cent., free of tax, on the ordinary shares, making 17½ per cent., £50,000; to reserve, £10,000; carried forward, £39,313.

Murex, Limited.—Trading profit, £216,335; dividends and interest received, etc., £62,406; balance, after expenses, £271,162; brought in, £77,730; interim dividend of 2s. per share, £42,204; preference dividend, £3,500; to obsolescence reserve, £40,000; to investment reserve, £15,760; available after depreciation and income tax, £196,668; final dividend of 3s. per share, £63,307; to general reserve, £100,000; carried forward, £33,362.

British Piston Ring Company, Limited. — Profit, including profit on sale of investments, and after providing for depreciation and taxation, £50,598; brought in £28,254; "A" preference dividend, £1,500; "B" preference dividend from date of issue, £2,318; interim dividend on 400,000 ordinary shares at 7½ per cent., £7,500; final dividend of 15 per cent. on 600,000 ordinary shares, £22,500; to general reserve, £15,000; carried forward, £30,034.

New Companies

(From the Register compiled by Jordan & Sons, Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)

Magnesite Traders, Limited, 52, New Broad Street, London, E.C.—Capital, £1,000.

Furnace Linings Company, Limited, 39/53, Nursery Street, Sheffield.—Capital, £500. Directors: R. B. Hodgson and L. S. Hodgson.

Adaptable Moulding Machine Company, Limited, 62, Stanhope Street, Birmingham.—Capital, £4,000. Directors: W. O'Keefe and J. W. Gardom.

John Redgate (Ironfounders), Limited.—Capital, £5,000. Directors: L. A. Bailey, "Hillsley," Clifton Lane, Raddington, Notts; J. G. Bailey.

Robert Mansell & Son, Limited.—Capital, £2,000 in £1 shares. Brass, bronze and other metal founders, etc. Directors: F. Wheeler, 83, Orphanage Road, Erdington, Birmingham; F. W. L. Wheeler.

Acrow (Engineers), Limited.—Capital, £1,000. Engineers, ironfounders, etc. Directors: A. V. Bauscher, 178, Goldhurst Terrace, Hampstead, London, N.W.; W. A. de Vigier, and W. Landauer.

Contracts Open

Cairo, November 30.—Pipes, valves and water-meters, for the Egyptian Ministry of Public Works. The Department of Overseas Trade. (Reference T.Y. 30,841.)

East Bergholt, October 21.—3,883 yds. of 4-in. and 638 yds. of 3-in. cast-iron water mains; steel framed water tower and tanks of 14,400 galls. capacity, for the Samford Rural District Council. Mr. H. Watling, surveyor, 5, Queen Street, Ipswich. (Fee £4 4s., returnable.)

Personal

SIR BERKELEY SHEFFIELD, Bart., a director of Federated Foundries, Limited, has been elected the Charter Mayor of Scunthorpe.

MR. A. L. FAWKES, metallurgist with the Cronite Foundry Company, Limited, Tottenham, has been made a Freeman of the City of London.

DR. T. SWINDEN, director of research with the United Steel Companies, Limited, has been nominated President of the Sheffield University Association.

MR. J. BRUCE JONES, of Jones & Campbell, Limited, Torwood Foundry, Larbert, has received a presentation of a silver tea-service from the staff and employees on the occasion of his marriage.

SIR JAMES LITHGOW, chairman of Wm. Beardmore & Company, Limited, of Glasgow, who is making a good recovery from his illness, hopes to resume business duties before the end of this month.

MR. GEORGE WINCHCOLE has received a gold watch from the Falkirk Iron Company, Limited, on the occasion of his retirement after fifty years' service with the firm. The presentation was made by Capt. H. J. Kennard, chairman of the company.

MR. V. JOBSON, chairman and managing director of Qualcast, Limited, Derby, has made a personal offer of 500 guineas to the Derbyshire Royal Infirmary Saturday Fund Committee, if the members can raise another 500 guineas by the end of November.

MR. ALBERT E. THOMPSON, senior governing director and chairman of John Thompson Engineering Company, Limited, received an illuminated address from employees of the six associated home companies, two Australian companies, and the representatives in India and South Africa, on attaining his 70th birthday.

Will

ANGUS, JONATHAN, of London, consulting engineer and director of the Bengal Iron Company, Limited £19,488

Obituary

MR. DAVID JENKINS, foreman patternmaker at the Rose Street Foundry & Engineering Company, Limited, Inverness, died recently.

MR. H. FIDDER has died from burns received while fluxing metal at the works of Wembley Aluminium, Limited. He was 26 years of age.

Forthcoming Events

OCTOBER 19.

Sheffield Society of Engineers and Metallurgists:—"Nickel." Paper by A. P. Hague, at Mappin Hall, Department of Applied Science, St. George's Square, Sheffield, at 7.30 p.m.

OCTOBER 21.

Manchester Metallurgical Society:—Presidential Address, by Prof. F. C. Thompson, at Constitutional Club, St. Ann's Street, Manchester, at 7 p.m.

OCTOBER 23.

Institution of Mechanical Engineers:—Presidential Address, by Sir Nigel Gresley, at Storey's Gate, St. James's Park, London, S.W.1, at 6 p.m.

Institute of British Foundrymen

OCTOBER 17.

Scottish Branch, Falkirk Section:—Joint meeting with the Scottish Section of The Institute of Vitreous Enamellers: "Enamelling Shop Ventilation." Paper by W. N. Howden, at the Temperance Café, Falkirk, at 7.30 p.m.

OCTOBER 23.

Middlesbrough Branch:—"Cupola Refractories." Paper by W. J. Rees, M.Sc., at the Cleveland Scientific and Technical Institute, Corporation Road, Middlesbrough, at 7.45 p.m.

OCTOBER 24.

Newcastle-upon-Tyne Branch:—"Science in Relation to the Foundry." Paper by E. C. Pigott, at Neville Hall, Westgate Road, Newcastle-upon-Tyne, at 6.15 p.m.

Wales and Monmouth Branch:—"Melting Metals in the Foundry." Paper by S. E. Dawson, at University College, Newport Road, Cardiff, at 6.30 p.m.

OCTOBER 23 AND 24.

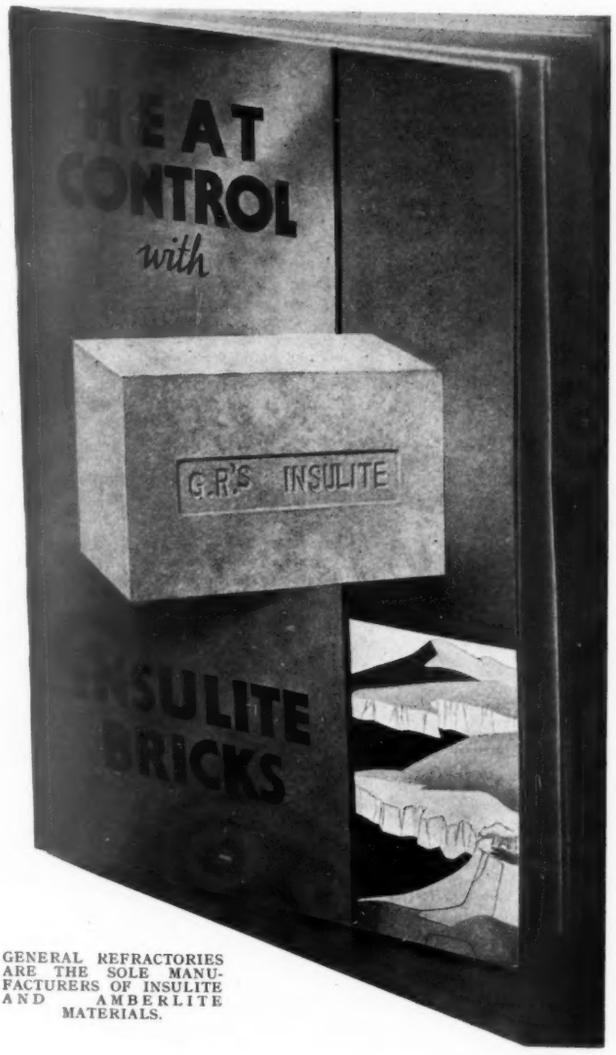
Birmingham, Coventry and West Midlands Branch, and London Branch:—Joint meeting in London. Visit to the Royal Arsenal, Woolwich. "Some Factors Affecting the Production of Sand Castings." Paper by E. W. Wynn and D. Hope; "The Application of Science to the Control of Foundry Sands." Paper by H. H. Shepherd.

The Institute of Vitreous Enamellers

OCTOBER 17.

Scottish Section:—Joint meeting with the Falkirk Section of the Institute of British Foundrymen; "Enamelling Shop Ventilation." Paper by W. N. Howden, at the Temperance Café, Falkirk, at 7.30 p.m.

Write for this NEW booklet



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MANUFACTURERS OF HEAT RESISTING AND HEAT INSULATING MATERIALS OF EVERY DESCRIPTION.

Raw Material Markets

There is little change to report in the condition of the iron and steel markets, which are very active. Consumers are continually endeavouring to find new sources of production from which they might obtain further material, but they are meeting with little success. Outputs are fully disposed of over a lengthy period.

Pig-Iron

MIDDLESBROUGH.—Although no changes in prices are anticipated before the end of March, it is almost certain that quotations for pig-iron will be advanced for the second quarter. Makers have sold most of their outputs up to March at current prices, but costs of production are steadily increasing from several directions and the burden is likely to be passed on to the consumer. As a result, makers are reluctant to enter into contracts involving deliveries after the expiration of this period. Present values are based on No. 3 Cleveland G.M.B. at 75s., No. 1 foundry iron 77s. 6d., and No. 4 foundry and No. 4 forge iron 74s. per ton, delivered Middlesbrough or Falkirk.

Deliveries of East Coast hematite are heavy against existing contracts, but little new business has been arranged. Export deliveries have only been small. East Coast mixed numbers are quoted at a minimum figure of 85s., less 5s. rebate, for deliveries on the North-East Coast.

LANCASHIRE.—Consumption of pig-iron in this area is on a good scale and large tonnages are regularly changing hands. In view of the possibility of an advance in prices makers are not any too keen to add to their present commitments, but new business is by no means out of the question. Offers of Staffordshire, Derbyshire and Lancashire brands of No. 3 foundry iron equal to Derbyshire, for delivery in the Lancashire price zone, are quoted on the basis of 83s. per ton, with Northants at 81s. 6d., and Derbyshire forge iron at from 78s. to 80s., according to the class of user. Scottish No. 3 is on offer at around 90s., West Coast hematite at 93s 6d., and East Coast at 93s., all delivered equal to Manchester.

MIDLANDS.—Very active conditions continue to prevail in this area, and deliveries into consumption are substantial. All grades of iron are well taken up and in some cases stocks are having to be reduced in order to meet the demand. The possibility of a serious shortage later on is by no means unlikely. The controlled quotations, delivered to Birmingham and Black Country stations, are 77s. 6d. for Northants No. 3 and 80s. for Derbyshire, Lincolnshire and North Staffordshire No. 3, these prices being subject to a small sliding-scale rebate to large consumers. The prices of forge iron remain at 5s. per ton below No. 3 foundry if required for puddling, and 3s. less if used in the foundries. The general engineering, jobbing and motor industries are taking up large tonnages of special irons and their prospects are excellent. Low-phosphorus pig-iron is quoted from 92s. 6d. to 100s., with Scottish around 92s. 6d., medium-phosphorus iron from 82s. 6d. to 90s., and refined iron at £6 10s., minimum, up to £8 10s. per ton, delivered this area. The price of the latter material only is under control. West Coast hematite is receiving numerous inquiries, as, also, are other grades. Current prices, including delivery in this area, are £4 17s. for West Coast mixed numbers, £4 16s. for East Coast No. 3 and £4 15s. 6d. for Welsh mixed numbers. These figures are subject to an increase of 1s. 6d. per ton if delivered into works in 10-ton lots.

SCOTLAND.—Supplies of pig-iron continue to be difficult to obtain, and the market remains firm. Foundry iron has changed hands, but chiefly in small tonnages, while there is no basic iron on offer. No. 3 foundry is still quoted at 79s. f.o.t. furnaces, with 2s. 6d. extra for No. 1. Trade with the light-castings founders is satisfactory and their future is likely to be very busy. No. 3 Cleveland iron is nominally quoted at 75s. f.o.t. Falkirk and 78s. f.o.t. Glasgow. Local steelworks are all active, with excellent prospects. Prices of steel-making irons are unchanged as follow:—Mixed numbers East Coast, West Coast and Scottish hematite, 85s. 6d., less 5s. rebate; basic, British and Indian, 75s., less 5s. rebate, all delivered steelworks.

Coke

Makers of foundry coke have all disposed of their outputs over a lengthy period. Consumers have generally contracted for their winter needs at current prices, which are expected to rise in the near future. For delivery in Birmingham and district, best Durham coke is quoted between 40s. and 42s. 6d., and Welsh from 40s. to 50s. per ton.

Steel

In spite of the record production of steel, the demand would appear to be growing more rapidly than output, says the official report of the London Iron and Steel Exchange. In most departments of the industry the manufacturers are concentrating upon distributing their make equally among customers rather than upon seeking new business. Most consumers have covered their prospective needs as far forward as suppliers are prepared to commit themselves; but it is not easy to arrange satisfactory delivery dates for new transactions. The works producing semi-finished steel are operating at capacity, but difficulty is experienced in meeting consumers' requirements. Users' fears that a shortage will develop later in the year, however, have been allayed by arrangements for an increase in the imports of this class of material over the fourth quarter. The demand for finished steel of all descriptions shows no signs of relaxing, and it is practically impossible to place orders excepting for far forward delivery.

Scrap

The demand for scrap on the Cleveland market is advancing steadily. Price difficulties had prevented the transaction of business, merchants demanding 60s. per ton for heavy melting steel, while users were unwilling to pay more than 57s. 6d. The higher price has now been conceded and business is more active. There are numerous inquiries for machinery metal at 67s. 6d. and foundry cast-iron scrap at 65s. per ton. There is little change to report in the condition of the Midland market, which remains active. Heavy iron and steel is at 52s. 6d. and mixed iron and steel at 51s. 6d. Heavy unsheared wrought iron is at 65s. to 67s. 6d. Heavy machinery is at 70s., good heavy at 65s., and clean light at 52s. 6d. to 55s. Short, heavy, steel scrap, as used in the foundries, is at 65s. per ton, delivered works. On the Scottish market consumption is on a good scale and a few cargoes have been imported. First-class heavy steel scrap remains at 57s. 6d., with heavy basic, or heavy iron and steel scrap mixed, at 5s. per ton less. Machinery cast-iron scrap, in pieces not exceeding 1 cwt., is at 69s. to 70s., with ordinary cast iron, to the same specification, at 64s. to 65s. per ton, delivered f.o.t. consumers' works.

Metals

Copper.—Some moderate tonnages have changed hands during the past week and the tone of the market is firm. The price of both cash and three months' copper rose well above the £40 mark this week, which is the highest level reached since 1932. As a result, the question of a further increase in production quotas is under review, as producers generally wish to avoid a jump in prices. It would appear that an increase to 10 cents per lb. in the United States is less likely, at any rate in the immediate future. The German output of refined copper in August was 12,630 metric tons, while the smelter output was 5,433 tons. These figures compare with 12,202 tons and 5,036 tons respectively for the previous month.

Daily market prices :—

Cash.—Thursday, £39 13s. 9d. to £39 15s.; Friday, £39 17s. 6d. to £40; Monday, £40 5s. to £40 6s. 3d.; Tuesday, £40 11s. 3d. to £40 12s. 6d.; Wednesday, £40 18s. 9d. to £41.

Three Months.—Thursday, £39 16s. 3d. to £39 17s. 6d.; Friday, £40 to £40 1s. 3d.; Monday, £40 7s. 6d. to £40 8s. 9d.; Tuesday, £40 13s. 9d. to £40 15s.; Wednesday, £40 18s. 9d. to £41.

Tin.—The weekly market review published by Rudolf Wolff & Company, states that "business with consumers is satisfactory, a fairly active demand being reported in this country, where the tinplate manufacturers still have ample orders on their books. On the Continent some irregularity has prevailed, while in the United States active conditions have been reported. The outlook is still very difficult to determine, for, on the one hand, consumption is definitely good and seems likely to undergo further expansion in the future, while the position in Bolivia is uncertain and some doubt still arises as to whether she will be able to fulfil her quota of 75 per cent. On the other hand, the renewal of the restriction scheme at the end of the year remains in abeyance pending negotiations which are still taking place with Siam, and in respect of which, though it is generally expected that agreement will be reached, there is no absolute certainty. Whilst this uncertainty prevails and conflicting rumours in consequence are in circulation from time to time, prices are apt to fluctuate erratically."

Metal Exchange quotations were as follow :—

Cash.—Thursday, £202 10s. to £202 15s.; Friday, £202 15s. to £203; Monday, £201 to £201 5s.; Tuesday, £197 10s. to £198; Wednesday, £200 to £200 5s.

Three Months.—Thursday, £199 5s. to £199 10s.; Friday, £199 10s. to £199 15s.; Monday, £198 5s. to £198 15s.; Tuesday, £196 to £196 10s.; Wednesday, £198 5s. to £198 10s.

Spelter.—There has been a moderate demand on trade account and consumption has been satisfactorily maintained. According to statistics issued by the American Zinc Institute, production in the United States during September was slightly lower than in August, at 42,283 short tons. Stocks, at 76,630 tons, reveal a sharp decrease of 9,564 tons.

Official quotations were as follow :—

Ordinary.—Thursday, £13 17s. 6d.; Friday, £13 17s. 6d.; Monday, £13 18s. 9d.; Tuesday, £14; Wednesday, £14 3s. 9d.

Lead.—Consumption in this country is reported to be well maintained. Supplies of prompt metal on the market are rather scarce, but the resumption of operations at the Hoboken smelter has relieved the position slightly, although Spain remains virtually a non-producer. Active conditions rule in the United States.

Day-to-day quotations :—

Soft Foreign (Prompt).—Thursday, £18 2s. 6d.; Friday, £18 6s. 3d.; Monday, £18 5s.; Tuesday, £18 2s. 6d.; Wednesday, £18 5s.

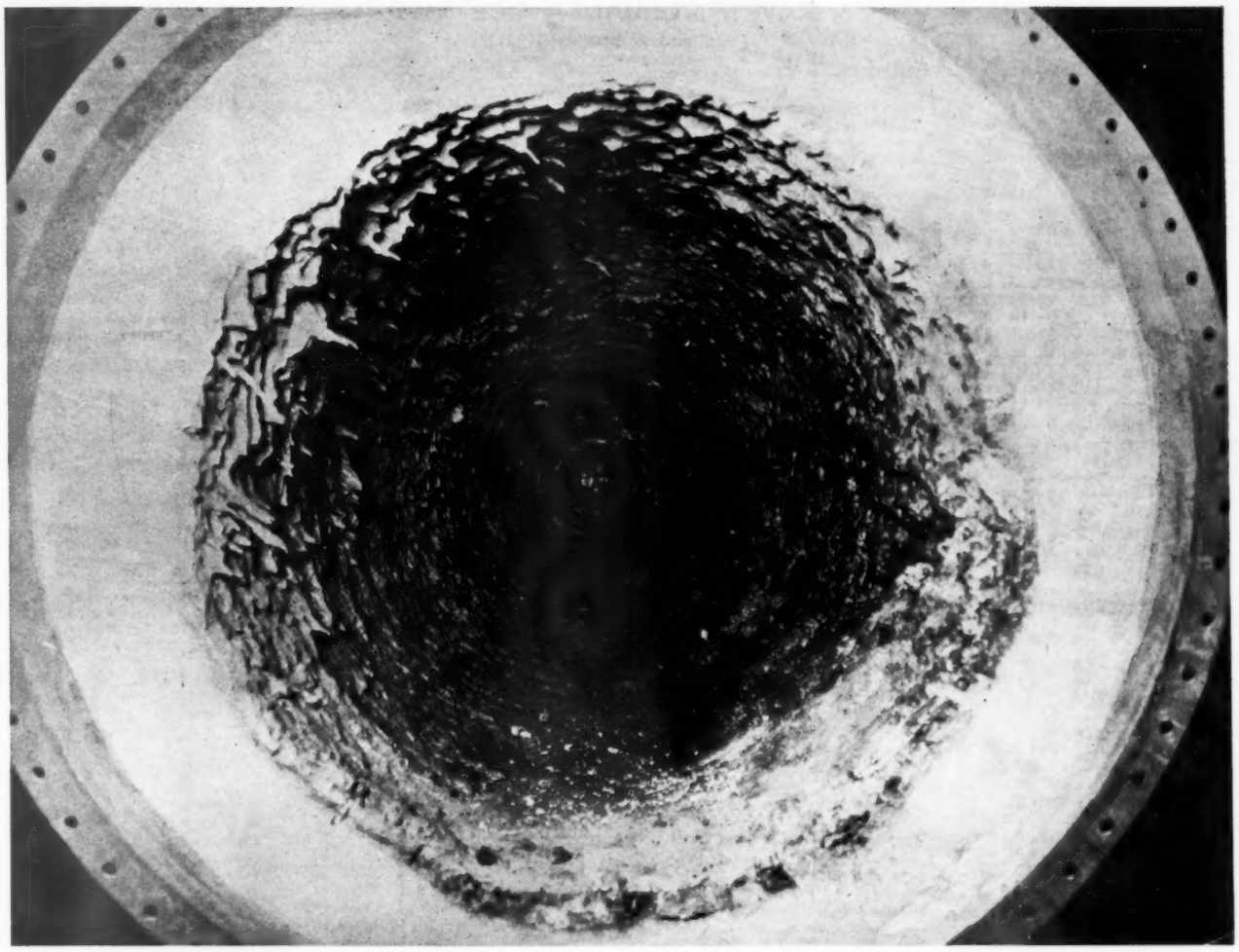
Company Meeting

Staveley Coal & Iron Company, Limited

Presiding at the annual meeting of the Staveley Coal & Iron Company, Limited, SIR WILLIAM BIRD (chairman) said the demands on their foundries during the past year had been exceptionally heavy. Their sand-spun pipe plant, which was erected in 1931, had been working to capacity. This plant was the only one of its kind in existence in this country. A plant for the production of small pipes 12 ft. in length was completed and began production in April of this year and was now being kept fully employed. It was an entirely different method from the sand-spun process and they sold its product under the name of "metal-spun pipes." A larger plant on similar principles for the manufacture of pipes both of 12 ft. and 18 ft. lengths was now in course of erection and should commence manufacture early in the new year. Owing to the increased production of pipes it was becoming very difficult to cope with the demands for special castings. Designs were being got out for the commencement of a new "special" foundry shop.

Tocco Process

Tocco is the name given a process for the selective surface hardening of crankshafts, now being operated by the Ohio Crankshaft Company, of Cleveland. According to "Steel," the crankshafts are heat-treated to give maximum toughness, then they are machined and ground, being left full. The selective process, which employs high-frequency current and a spray coolant, is then applied, after which the crankshaft is finally ground. The main advantage is claimed to be a reduction in machining time.



950 tons of metal melted—

The above photograph shows the condition of an 04 grade Albino lining in a 5-ton Brackelsberg furnace after 255 heats. You will observe the lining has worn back evenly and it is still approximately 8" in thickness. The 04 grade is specially produced for rotary furnaces, but there are other grades for lining cupolas, converters and ladles. This photograph is reproduced by courtesy of James Howden and Company (Land) Ltd.

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RAW MATERIALS—PRICE LIST

(Wednesday, October 14, 1936)

COPPER

	£ s. d.
Standard cash	40 18 9
Three months	40 18 9
Electrolytic	45 5 0
Tough	43 10 0
Best selected	44 0 0
Sheets	72 0 0
India	54 7 6
Wire bars	45 5 0
Ingot bars	45 5 0
H.C. wire rods	49 0 0
Off. av. cash, Sept.	38 19 0 9/28
Do., 3 mths., Sept.	39 3 5 1/4
Do., Sttlmnt., Sept.	38 18 10 5/11
Do., Electro, Sept.	43 10 1 1/11
Do., B.S., Sept.	43 1 11 1/2
Do., wire bars, Sept.	43 14 10 7/11
Solid drawn tubes	11d.
Brazed tubes	11d.
Wire	6 1/2d.

BRASS

Solid drawn tubes	10d.
Brazed tubes	12d.
Rods, drawn	9d.
Rods, extd. or rlld.	5d.
Sheets to 10 w.g.	8 1/2d.
Wire	8d.
Rolled metal	7 1/2d.
Yellow metal rods	5d.
Do. 4 × 4 Squares	5 1/2d.
Do. 4 × 3 Sheets	5 1/2d.

TIN

	£ s. d.
Standard cash	200 0 0
Three months	198 5 0
English	200 5 0
Bars	202 10 0
Straits	202 0 0
Australian	200 0 0
Eastern	203 5 0
Banca (nom.)	202 0 0
Off. av. cash, Sept.	194 17 7 5/11
Do., 3 mths., Sept.	192 5 2 5/11
Do., Sttlmt., Sept.	194 16 1 7/11

SPELTER

	£ s. d.
Ordinary	14 3 9
Remelted	13 5 0
Hard	11 15 0
Electro 99.9	16 3 9
English	14 17 6
India	12 15 0
Zinc dust	19 15 0
Zinc ashes	4 10 0
Off. aver., Sept.	14 0 7 1/2
Aver. spot, Sept.	13 18 1 1/2

LEAD

	£ s. d.
Soft foreign ppt.	18 5 0
Empire	18 17 6
English	20 5 0
Off. average, Sept.	17 19 9 3/4
Average spot, Sept.	18 0 2 1/2

ALUMINIUM

Ingots	£100 to £105
Wire	1/3 to 1/4 lb.
Sheet and foil	1/2 to 1/4 lb.

ZINC SHEETS, &c.

Zinc sheets, English	24 0 0 to 24 10 0
Do., V.M. ex-whse.	24 0 0 to 24 10 0
Rods	26 0 0

ANTIMONY

English	67 10 0 to 68 10 0
Chinese, ex-whse.	56 0 0
Crude, c.i.f.	26 10 0

QUICKSILVER

Quicksilver	13 17 6 to 13 18 0

FERRO-ALLOYS AND STEEL-MAKING METALS

Ferro-silicon—	
25%	8 17 6
45/50%	11 10 0 to 12 15 0
75%	16 12 6 to 17 17 6
Ferro-vanadium—	
35/50%	12/8 lb. Va.
Ferro-molybdenum—	
70/75% carbon-free	4/6 lb. Mo.
Ferro-titanium—	
20/25% carbon-free	9d. lb.
Ferro-phosphorus, 20/25%	£21 to £22
Ferro-tungsten—	
80/85%	3/1 1/2 lb.
Tungsten metal powder—	
98/99%	3/3 lb.
Ferro-chrome—	
2/4% car.	33 0 0
4/6% car.	21 10 0
6/8% car.	21 0 0
8/10% car.	21 0 0
Ferro-chrome—	
Max. 2% car.	33 10 0
Max. 1% car.	36 5 0
Max. 0.50% car.	37 5 0
70% carbon-free	9 1/2d. lb.
Nickel—99.5/100%	£200 to £205
"F" nickel shot	£184 0 0
Ferro-cobalt, 98/99%	6/3 to 6/9 lb.
Metallic chromium—	
96/98%	2/5 lb.
Ferro-manganese—	
76/80% loose	£11 15 0 to 12 5 0
76/80% packed	£12 15 0 to 13 5 0
76/80% export	£10 5 0
Metallic manganese—	
94/96% carbon-free	1/3 lb.

Per ton unless otherwise stated, basis 2-ton lots.

HIGH-SPEED TOOL STEEL

Finished bars, 14% tungsten	2s. 0d.
Finished bars, 18% tungsten	2s. 9d.

Per lb. net, d/d buyers' works.

Extras—	
Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under 1/4 in. to 1/4 in.	3d. lb.
Do., under 1/4 in. to 1/16 in.	1/- lb.
Flats, 1/4 in. × 1/4 in. to under 1 in. × 1/8 in.	3d. lb.
Do., under 1/4 in. × 1/4 in.	1/- lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

SCRAP

South Wales—	£ s. d.	£ s. d.
Heavy steel		3 4 0
Mixed iron and steel	2 18 0 to 3 0 0	
Heavy cast iron	2 18 0 to 3 0 0	
Good machinery	3 2 0 to 3 4 0	
Cleveland—		
Heavy steel	2 17 6 to 3 0 0	
Steel turnings		2 5 0
Heavy cast iron		3 5 0
Heavy machinery		3 7 6
Midlands—		
Light cast-iron scrap	2 12 6 to 2 15 0	
Heavy wrought iron	3 5 0 to 3 7 6	
Steel turnings		2 0 0
Scotland—		
Heavy steel		2 17 6
Ordinary cast iron	3 4 0 to 3 5 0	
Engineers' turnings		2 2 6
Cast-iron borings		1 18 0
Wrot-iron piling	3 8 9 to 3 10 0	
Heavy machinery	3 9 0 to 3 10 0	

London—Merchants' buying prices, delivered yard.

Copper (clean)	33 0 0
Brass	20 10 0
Lead (less usual draft)	16 10 0
Tea lead	12 0 0
Zinc	8 10 0
New aluminium cuttings	74 0 0
Braziery copper	30 0 0
Gunmetal	31 0 0
Hollow pewter	145 0 0
Shaped black pewter	110 0 0

PIG-IRON

N.E. Coast (d/d Tees-side area)—	
Foundry No. 1	77/6
,, No. 3	75/-
,, No. 4	74/-
Forge No. 4	74/-
Hematite No. 1	85/6*
Hematite M/Nos.	85/-*
N.W. Coast—	
Hem. M/Nos. d/d Glas.	85/6*
,, d/d Birm.	97/-*
Malleable iron d/d Birm.	125/-
Midlands (d/d Birmingham dist.)—	
Staffs No. 4 forge	77/-
,, No. 3 fdry.	80/-
Northants forge	74/6
,, fdry. No. 3	77/6
,, fdry. No. 1	80/6
Derbyshire forge	77/-
,, fdry. No. 3	80/-
,, fdry. No. 1	83/-
Scotland—	
Foundry, No. 1, f.o.t.	81/6
,, No. 3, f.o.t.	79/-
Cleveland No. 3, Glasgow	78/-
,, ,, Falkirk	75/-
Scottish hem. M/Nos. d/d	85/6*
Sheffield (d/d district)—	
Derby forge	74/6
,, fdry. No. 3	77/6
Lincs forge	74/6
,, fdry. No. 3	77/6
W.C. hematite	91/-*
Lancashire (d/d eq. Man.)—	
Derby fdry. No. 3	83/-
Staffs fdry. No. 3	83/-
Northants fdry. No. 3	81/6
Cleveland fdry. No. 3	83/-
Dalzell, No. 3 (special)	102/6 to 105/-
Glengarnock, No. 3	90/-
Clyde, No. 3	90/-
Monkland, No. 3	90/-
Summerlee, No. 3	90/-
Eglinton, No. 3	90/-
Gartsherrie, No. 3	90/-
Shotts, No. 3	90/-

* Subject to a rebate of 5s. per ton under certain conditions.

FINISHED IRON AND STEEL

Usual district deliveries for iron; delivered consumer's station for steel.

Iron—	£ s. d.	£ s. d.
Bars (cr.)		10 10 0
Nut and bolt iron	8 17 6 to 9 7 6	
Hoops	11 7 6 and up.	
Marked bars (Staffs) f.o.t.		13 0 0
Gas strip	11 7 6 and up.	
Bolts and nuts, 3/4 in. × 4 in.	16 0 0 and up.	
Steel—		
Plates, ship, etc.	9 7 6 to	9 10 0
Boiler plts.	9 17 6 to	10 0 0
Chequer plts.		11 0 0
Angles		9 0 0
Tees		10 0 0
Joists		9 7 6
Rounds and squares, 3 in. to 5 1/2 in.		10 0 0
Rounds under 3 in. to 1/4 in. (Untested)		9 7 0
Flats—8 in. wide and over		9 5 0
,, under 8 in. and over 5 in.		9 10 0
Rails, heavy	8 5 0 to	8 10 0
Fishplates		12 10 0
Hoops (Staffs)		10 2 0
Black sheets, 24g. (4-t. lots)		12 0 0
Galv. cor. shts. (,,)		14 0 0
Galv. flat shts. (,,)		14 10 0
Galv. fencing wire, 8g. plain		15 0 0
Billets, soft		6 2 6
Billets, hard	7 2 6 to	7 7 6
Sheet bars		6 0 0
Tin bars		6 0 0

PHOSPHOR BRONZE

	Per lb. basis
Strip	10 1/4d.
Sheet to 10 w.g.	11 1/4d.
Wire	12 1/2d.
Rods	12d.
Tubes	14d.
Castings	12 1/4d.

Delivery 3cwt. free.
10% phos. cop. £30 above B.S.
15% phos. cop. £35 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

NICKEL SILVER &c.

	Per lb.
Ingots for raising	7d. to 1/1
Rolled—	
To 9 in. wide	1/1 to 1/7
To 12 in. wide	1/1 1/4 to 1/7 1/4
To 15 in. wide	1/1 1/2 to 1/7 1/2
To 18 in. wide	1/2 to 1/8
To 21 in. wide	1/2 1/2 to 1/8 1/2
To 25 in. wide	1/3 to 1/9
Ingots for spoons and forks	7d. to 1/3 1/2
Ingots rolled to spoon size	10d. to 1/6 1/2
Wire round—	
to 10g.	1/4 1/2 to 1/11 1/2

with extras according to gauge.
Special 5ths quality turning rods in straight lengths, 1/3 1/2 upwards.

AMERICAN IRON AND STEEL

At Pittsburgh unless otherwise stated.

	Dols.
No. 2 foundry, Phila.	21.31
No. 2 foundry, Valley	19.50
No. 2 foundry, Birm.	15.88
Basic, Valley	19.00
Malleable, Valley	19.50
Grey forge, Valley	19.00
Ferro-mang. 80%, seaboard	75.00
O.-h. rails, h'y, at mill	36.37 1/2
Billets	32.00
Sheet bars	32.00
Wire rods	40.00
	Cents.
Iron bars, Chicago	1.80
Steel bars	2.05
Tank plates	1.90
Beams, etc.	1.90
Skelp, grooved steel	1.80
Steel hoops	1.95
Sheets, black, No. 24	2.60
Sheets, galv., No. 24	3.20
Wire nails	2.05
Plain wire	2.55
Barbed wire, galv.	2.60
Tinplates, 100-lb. box	$5.25

COKE (at ovens)

Welsh foundry	30/- to 32/6
,, furnace	24/6 to 25/-
Durham foundry	24/6
,, furnace	21/6
Scotland, foundry	30/-
,, furnace	25/- to 26/-

TINPLATES

f.o.b. Bristol Channel ports.

I.C. cokes 20×14 per box	18/9
,, 28×20 ,,	37/6
,, 20×10 ,,	26/9 to 27/-
,, 18 3/4×14 ,,	19/6
C.W. 20×14 ,,	15/6 to 15/9
,, 28×20 ,,	33/9 to 34/-
,, 20×10 ,,	22/6 to 22/9
,, 18 3/4×14 ,,	15/3 to 15/9

SWEDISH CHARCOAL IRON & STEEL

Pig-iron	£6 0 0 to £7 0 0
Bars-hammered, basis	£16 0 0 to £16 10 0
Bars and nail-rods, rolled, basis	£15 15 0 to £16 0 0
Blooms	£10 0 0 to £12 0 0
Keg steel	£25 0 0 to £28 0 0
Faggot steel	£18 0 0 to £23 0 0
Bars and rods dead soft, st'l	£10 0 0 to £12 0 0

All per English ton, f.o.b. Gothenburg.
[Subject to an exchange basis of Kr. 18.16 to £1.]

DAILY FLUCTUATIONS

Standard Copper (cash)

		£ s. d.	
Oct. 8 ..	39 13 9	dec.	1/3
„ 9 ..	39 17 6	inc.	3/9
„ 12 ..	40 5 0	„	7/6
„ 13 ..	40 11 3	„	6/3
„ 14 ..	40 18 9	inc.	7/6

Electrolytic Copper

		£ s. d.	
Oct. 8 ..	44 7 6	inc.	2/6
„ 9 ..	44 10 0	„	2/6
„ 12 ..	44 15 0	„	5/-
„ 13 ..	45 0 0	„	5/-
„ 14 ..	45 5 0	„	5/-

Standard Tin (cash)

		£ s. d.		
Oct. 8 ..	202 10 0	inc.	10/-	
„ 9 ..	202 15 0	„	5/-	
„ 12 ..	201 0 0	dec.	35/-	
„ 13 ..	197 10 0	„	70/-	
„ 14 ..	200 0 0	inc.	50/-	

Tin (English ingots)

		£ s. d.		
Oct. 8 ..	202 10 0	inc.	10/-	
„ 9 ..	202 15 0	„	5/-	
„ 12 ..	201 0 0	dec.	35/-	
„ 13 ..	198 0 0	„	60/-	
„ 14 ..	200 5 0	inc.	45/-	

Spelter (ordinary)

		£ s. d.		
Oct. 8 ..	13 17 6	No	change	
„ 9 ..	13 17 6	„	„	
„ 12 ..	13 18 9	inc.	1/3	
„ 13 ..	14 0 0	„	1/3	
„ 14 ..	14 3 9	„	3/9	

Spelter (Electro, 99.9 per cent.)

		£ s. d.		
Oct. 8 ..	15 17 6	dec.	1/3	
„ 9 ..	15 17 6	No	change	
„ 12 ..	15 18 9	inc.	1/3	
„ 13 ..	16 0 0	„	1/3	
„ 14 ..	16 3 9	„	3/9	

Lead (soft foreign, prompt)

		£ s. d.		
Oct. 8 ..	18 2 6	inc.	1/3	
„ 9 ..	18 6 3	„	3/9	
„ 12 ..	18 5 0	dec.	1/3	
„ 13 ..	18 2 6	„	2/6	
„ 14 ..	18 5 0	inc.	2/6	

Lead (English)

		£ s. d.		
Oct. 8 ..	20 0 0	No	change	
„ 9 ..	20 5 0	inc.	5/-	
„ 12 ..	20 5 0	No	change	
„ 13 ..	20 0 0	dec.	5/-	
„ 14 ..	20 5 0	inc.	5/-	

AVERAGE MONTHLY PRICES OF UNMARKED BARS (SOUTH STAFFS)

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1901	8 0 0	7 10 0	7 5 0	7 0 0	6 10 0	6 10 0	6 10 0	6 10 0	6 15 0	6 15 0	6 15 0	6 15 0	6 17 11
1902	7 0 0	6 10 0	6 15 0	6 15 0	6 15 0	6 10 0	6 10 0	6 15 0	6 15 0	6 15 0	6 10 0	6 10 0	6 13 4
1903	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 7 0	6 5 0	6 9 4½
1904	6 5 0	6 5 0	6 5 0	6 5 0	6 10 0	6 5 0	6 0 0	6 0 0	6 0 0	6 0 0	6 0 0	6 0 0	6 2 11½
1905	6 5 0	6 5 0	6 0 0	5 17 6	5 15 0	5 15 0	5 15 0	5 15 0	6 0 0	6 5 0	6 15 0	6 15 0	6 1 10
1906	7 0 0	7 5 0	7 5 0	7 5 0	6 17 6	6 15 0	6 12 6	6 10 0	7 10 0	6 12 6	6 16 3	7 3 9	6 17 8
1907	7 3 9	7 5 0	7 5 0	7 5 0	7 5 0	7 7 6	7 5 0	7 7 6	7 7 6	7 7 6	7 7 6	7 5 0	7 5 11
1908	7 2 6	7 0 0	7 0 0	7 0 0	6 15 0	6 7 6	6 5 0	6 2 6	6 2 6	6 2 6	6 2 6	6 0 0	6 10 0½
1909	6 0 6	6 0 0	6 0 0	5 17 6	6 0 0	6 0 0	6 0 0	5 17 6	6 0 0	6 2 6	6 2 6	5 17 6	5 19 9
1910	6 2 6	6 3 4½	6 7 6	6 7 6	6 7 6	6 6 6	6 6 6	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 7
1911	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 10 0	6 12 6	6 16 6	6 7 0
1912	6 18 9	7 1 10	7 2 6	7 8 9	7 18 0	8 0 7	8 2 6	8 3 6	8 5 0	8 6 3	8 7 6	8 8 9	7 17 0
1913	8 11 6	8 10 7½	8 10 0	8 8 1½	8 2 0	8 0 0	7 17 6	7 11 6	7 8 9	7 5 6	6 18 1½	6 17 6	7 16 9
1914	6 17 6	6 15 7½	6 12 6	6 10 0	6 10 0	6 10 0	6 10 0	7 11 10½	8 0 0	7 12 6	7 5 7½	7 6 3	7 1 0
1915	7 11 6	8 5 11	8 8 9	9 6 0	10 3 2	10 19 2	11 12 6	11 13 1½	11 13 9	11 14 3	12 1 10½	13 0 9	10 6 0½
1916	13 7 6	13 10 8	13 12 9½	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 3 9
1917	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0½
1918	13 15 0	13 17 3	13 17 6	13 17 6	13 17 6	13 17 6	13 17 6	14 15 0	14 15 0	14 15 0	14 15 0	14 15 0	14 4 5
1919	15 10 0	16 5 0	17 15 0	17 15 0	20 15 0	21 0 0	21 0 0	22 0 0	22 0 0	22 0 0	22 0 0	22 7 6	20 1 8
1920	24 7 6	24 10 0	25 10 0	27 10 0	29 5 0	31 0 0	31 10 0	31 10 0	31 10 0	31 10 0	31 10 0	29 7 6	29 1 8
1921	26 17 3	25 0 0	23 0 0	21 0 0	19 0 0	18 5 0	16 0 0	16 0 0	15 14 0	14 0 0	13 6 8	13 0 0	19 4 5½
1922	13 0 0	12 3 9	11 14 0	11 11 10½	11 5 0	11 3 6	11 2 6	11 5 0	10 17 2½	10 16 3	10 13 0	10 12 6	11 7 0½
1923	10 16 10½	11 3 1½	12 2 6	12 8 9	12 11 6	12 1 3	11 15 11½	11 15 0	11 15 0	11 15 0	12 13 6	12 8 3	11 18 10½
1924	12 9 6	12 10 0	12 10 0	12 15 7½	12 17 6	12 17 6	12 17 6	12 17 6	12 17 6	12 14 0	12 12 6	12 12 6	12 14 3½
1925	12 12 6	12 12 6	12 12 6	12 12 6	12 12 6	12 7 6	12 7 6	12 7 6	12 4 6	11 18 6	11 13 9	11 13 0	12 6 2
1926	11 7 9½	11 5 0	11 5 0	11 5 0	11 3 9	11 3 9	11 5 0	12 0 0	13 0 0	*	15 7 6	12 19 0	12 0 2
1927	12 6 3	12 2 6	11 14 0	11 0 0	10 18 9	10 13 6	10 12 6	10 5 0	9 16 0	9 15 0	9 13 9	9 12 9	10 14 2
1928	9 12 6	9 12 6	9 11 0	9 10 0	9 8 4	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 3 6	9 1 3	9 7 0
1929	9 0 0	9 2 6	9 5 7½	9 9 4½	9 10 0	9 17 6	10 2 6	10 2 6	10 2 6	10 0 6	10 3 9	10 5 7	9 15 2½
1930	10 7 6	10 7 6	10 7 6	10 6 10½	10 6 3	10 5 0	10 2 6	10 2 6	10 2 6	10 2 6	10 2 6	10 2 6	10 4 7½
1931	10 2 6	10 0 0	10 0 0	10 0 0	9 18 1½	9 17 6	9 17 6	9 17 6	9 17 6	9 17 6	9 17 6	9 16 10½	9 18 0½
1932	9 15 0	9 15 0	9 15 0	9 15 0	9 13 9	9 11 3	9 10 0	9 10 0	9 10 0	9 8 3	9 5 0	9 5 0	9 10 11½
1933	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0
1934	9 5 0	9 8 1½	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 11 6
1935	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6
1936	9 12 6	9 15 0	10 2 6	10 2 6	10 2 6	10 2 6	10 6 3	10 10 0	10 10 0	—	—	—	—

* No quotation available owing to strike.

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YOUNG qualified Secretary, with 13 years' experience in the light casting trade, requires progressive position with a firm engaged in the same trade. Secretarial position preferred.—Reply Box 934, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

IRONFOUNDRY in Midlands requires Commercial Manager. Please write stating age, experience, and salary required, to SHAKESPEARE & VERNON, 83, Colmore Row, Birmingham.

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Correspondence should be addressed to the General Secretary, Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester, from whom full particulars can be obtained of this service.

Any employer wishing to communicate with a candidate should write to the General Secretary, quoting identification number.

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FOR private disposal. Ironfoundry in South Yorkshire now working to capacity, 80 to 100 tons per month. A good open business, mainly engineering castings up to 3 tons in weight. Retirement sole cause of sale. Fullest investigation permitted. No genuine offer of prompt cash will be refused.—Address Box 922, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

PATENT

THE proprietor of British Patent No. 277,537, dated January 10, 1927, relating to "A Method of Producing High Grade Silicon Iron," is desirous of entering into arrangements by way of a licence or otherwise, on reasonable terms, for the purpose of exploiting the above patent and ensuring its practical working in Great Britain.—Inquiries to B. SINGER, Steger Building, Chicago, Illinois.

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WANTED.—One Gutmann 9-ft. Rotating-table Sand-blasting Machine for 60 lbs. pressure; no compressor plant or dust extracting required. Must be in good condition.—Box 930, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

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TWO new Cupolas, 6 ft. dia., with Keith Blackman blowing fans, hoist and all equipment for standard grid voltage. Cheap to save second removal. These cupolas are complete with spark arrester, staging and all equipment. —Box 932, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

MACHINERY—*Continued*

SAND MIXERS AND AERATORS.—The "Breakir" Centrifugal Machine is *THE* machine. Outputs 10 cwts. to 8 tons per hr.—W. BREALEY & CO., LTD., Station Works, Ecclesfield, Sheffield.

NEW Dwarf Cupola, to melt 10 to 15 cwts. per hr. New Worm-geared Ladles, 5 tons, 25 cwts., 15 cwts. and 10 cwts. capacity. Ungeared Ladles, 15 cwts. and 10 cwts. capacity. Improved Cupola Spark Arresters.—T. DAVIES & SON, West Gorton, Manchester.

Tilghman Sandblast Barrel Plants; barrel sizes—60 in. x 40 in.; 36 in. x 20 in.; 20 in. x 30 in.

Tilghman Sandblast Cabinet Plants; 4 ft. 6 in. and 3 ft. 6 in. square (one for high pressure 70 lbs. per sq. in.); also small Cabinet 30 in. dia.

All complete with Air Compressors, etc.

Gas and Air Mixer by Sharpe & Preston, 2-in. outlet.

Six Osborne Pneumatic Jolt Press Moulding Machines, size 75J.

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Grimes Hand-ram Turn-over Machine; take boxes from 16" square up to 26" x 18".

Babcock W.T. BOILER, of 4,356 sq. ft. heating surface; 150 lbs. w.p.

VERT. COCHRAN BOILER; 12' 3" x 5' 6"; 100 lbs. w.p.

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Grams: "Forward." 'Phone: 23001 (10 lines).
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MISCELLANEOUS

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GENUINE Southport Wind Blown Sand, which makes best oil-sand cores. Prompt deliveries by road into works.
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SAND MERCHANT,
SOUTHPORT.

FLUIDITY TESTS.—Patterns for these tests as described in F.T.J. of September 24 by Carl F. Joseph. Made in aluminium from our master pattern. 35s. per set. We shall also be glad to have your inquiries for patterns in hard or soft woods for all kinds of engineering, large and small.—FURMSTON & LAWLOR, Pattern Makers, Letchworth.

MISCELLANEOUS—*Continued*

WHY WASTE MONEY by paying too high a price for your Blacking? Blacking of the highest quality, but quoted at very low prices, is obtainable from JACK HIBBERT & COMPANY, LIMITED, T.G. Dept., Octagon Works, Vicarage Road, Battersea, S.W.11. Send for free 1-cwt. sample for testing.

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Two No. 6 Ajax 36" × 24" jolt pattern draw machines. Price £55 each.

36" Metal Bandsaw, as new. Price £25.
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